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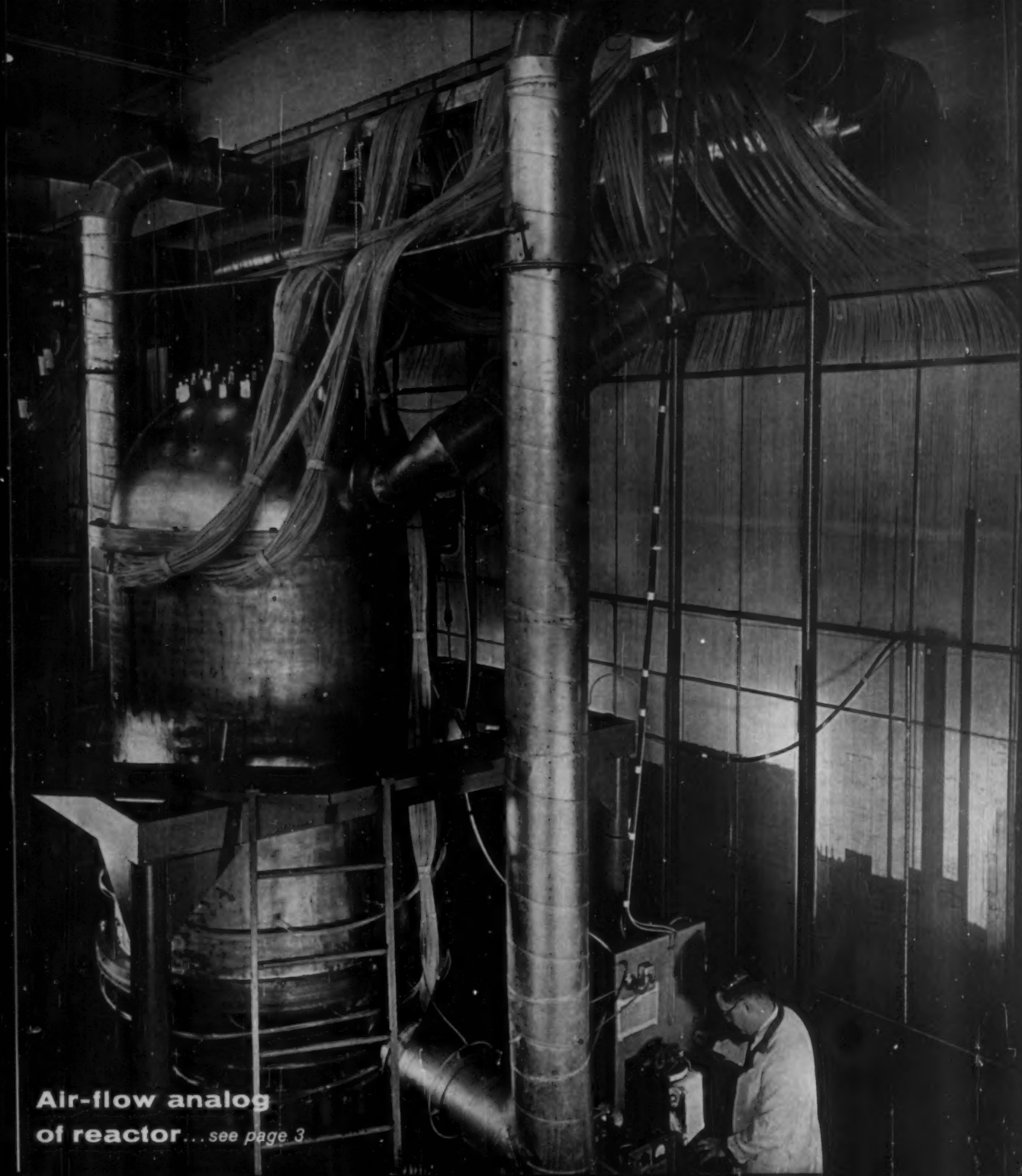
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · JANUARY 18, 1960



Air-flow analog of reactor... *see page 3*

here's the really new

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SPEED REDUCER

It was Designed to Provide: High Horsepower in a Smaller Unit • Centrifugally Cast Bronze Gears • Alloy Steel Worms Heat Treated By An Exclusive Process for Carrying Higher Loads • Fan Cooling for More Efficient Operation • Maximum Overhung Load-Carrying Capacity • Ribbed Housing for Maximum Strength and Heat Dissipation • Modern, Streamlined Design to Enhance Your Machine's Appearance.

Cleveland's new speed reducer line meets AGMA Standard 440.03 — which permits higher horsepower and torque ratings — provides you speed reduction at savings of 50% or more on cost per horsepower. All this, with no deviation from Cleveland's standards of quality and dependability.

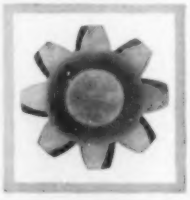
Remember, this strikingly new line of fan-cooled reducers — now available from one to forty horsepower — incorporates all the design knowledge gained by Cleveland's engineers over the past 47 years — plus all the advantages of modern metallurgical techniques and advanced manufacturing processes. Consult your Cleveland Representative for the complete story on this new speed reducer — or write us direct for Bulletin No. 405. It details input horsepower and output torque ratings, service factors, application and load classifications, as well as general over-all dimensions. **The Cleveland Worm & Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.**

A subsidiary of
Eaton Manufacturing Company
Affiliate: The Farval Corporation

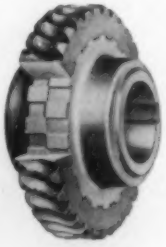
EATON

Check these new exclusive Cleveland features

Cleveland's Worm's, heat-treated by an exclusive process, possess a high degree of hardness throughout their entire thread thickness — and well below the worm's root diameter. This gives maximum thread strength and resistance to wear without losing the advantage of a tough core of medium hardness.



Centrifugal cast bronze rims have a greater density and a higher hardness, giving increased resistance to wear and fatigue pitting. They are centrifugally cast integral with cast iron centers on 6″ and smaller sizes. This permits strong mechanical keying of the two parts — without dependence on actual surface bond. Gear shaft extension diameters are especially large to permit greatly increased overhung load capacity.



Worm and gear shaft bearings are Timken taper roller type, providing adequate thrust and radial capacity. Worm bearings are mounted directly in the housing bore for greater rigidity.

CLEVELAND
Worm Gear
Speed Reducers

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

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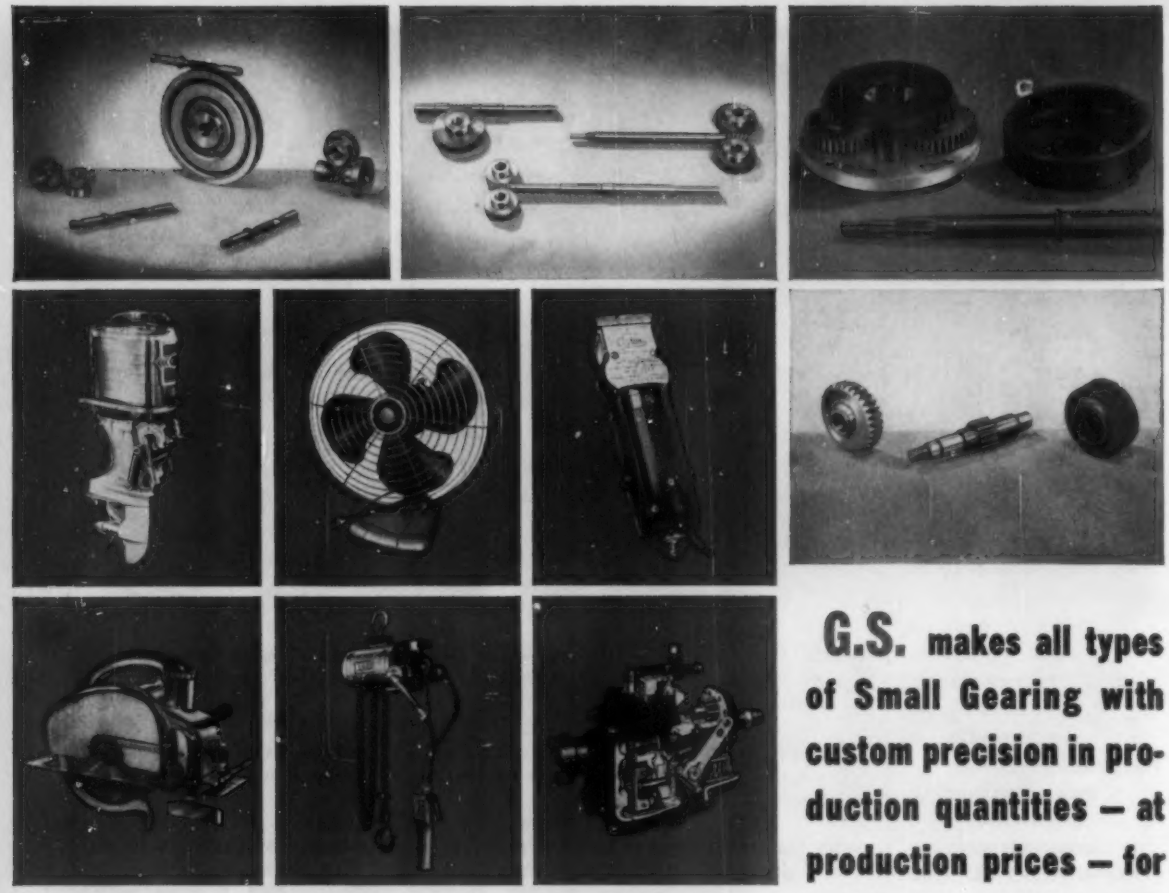

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INTERESTING TO NOTE

Models Guide Reactor Design

To run a nuclear power reactor economically you must keep the heat-transfer rates just below those that would cause burnout. This calls for accurate predictions of local flow rates throughout the core under all operating conditions. Mathematical solutions to the three-dimensional flow problems involved are not accurate enough to allow sufficiently small safety factors, so experimental study is often justified.

It is common practice to make a comprehensive model study of flow in a reactor to measure distribution of flow among the hundreds of parallel paths within the core. The same model allows study of pressure drops throughout the reactor, velocities influencing heat transfer to structural parts, and mixing of coolant between inlets and the core. Such studies are carried out in scale models duplicating all essential internal features of the reactor.

Any undesirable flow conditions found in the original design can be easily corrected in the model, and the modified model used as a basis for prototype design.

Our cover shows a quarter-scale model of a nuclear reactor set up for air-flow studies at Battelle Memorial Institute. It is being studied under the Experimental Gas Cooled Reactor design program being carried out by Kaiser engineers for the Atomic Energy Commission. The model is 5 ft dia, 12 ft high, constructed of fiberglass-reinforced epoxy resin. The aluminum core contains 248 simulated fuel elements, each with a flow-measuring orifice. Air from a 275-hp blower system enters two inlets at bottom of the model, and leaves through outlets at the top. Pressures at 700 locations in the model are measured on a large manometer panel in the background. Accuracy of flow measurements is held to within 0.3%.

Tanks for the Jeeps

One of the most useful machines to come out of World War II was the multipurpose "Jeep." Since entering civilian life under the trademarked name, Jeep, this versatile, ¼-ton vehicle has been put to work throughout the world. And now that so many of its components are interchangeable (see p 48), today's Army jeep should prove even more useful.

Any GI who went through the war can contribute interesting anecdotes relating to the jeep. However, one of the most daring and strategically important accomplishments took place at El Alamein during the crucial battle for Egypt. Generals Montgomery and Rommel were battling on even terms. Montgomery needed a diversionary maneuver to throw Rommel off balance, making him vulnerable for concentrated attack. One evening a caravan of jeeps left Monty's camp and headed into the desert. With only darkness to protect them the jeeps swept a wide arc

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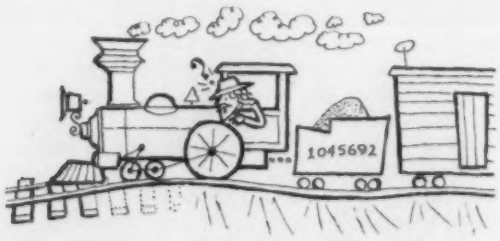
far behind the German lines. They concealed themselves on a strategic hilltop awaiting a convoy of Nazi gasoline trucks coming up to refuel the German Mark IV tanks engaged at the front. When the convoy arrived, the jeeps sped down, firing incendiaries. Within a matter of seconds, the jeeps were speeding back home, leaving an inferno of shattered trucks behind. When the tanks met for their refueling rendezvous they found nothing but seared sand. Without enough petrol to escape, many tanks were captured and the "Desert Fox" met a most severe setback.

Robert E Lee and the Rotting Railroad

When General Robert E Lee was making one of his heroic stands below Fredericksburg he ran into a most serious problem. Badly needed supplies from Georgia and the Carolinas were being delayed because of train derailments —ties under the railroad tracks had rotted. It wasn't learned until many years later that a wood fungus prevalent



in humid climates had caused those ties to rot. This wasn't the South's first trouble with fungi. Half a century earlier Thomas Jefferson had spoken out against wooden buildings in Virginia because they rotted too fast, and quickly became eyesores. With all his scientific insight, Jefferson couldn't link wood rot with fungus, but he did see that, in a Southern climate, wood structures didn't fare well.

Farmers in the Midwest have had troubles too. They learned years ago that mold-producing fungi did a lot more damage to their stored grain then rodents. The modern farmer has learned to control rats and insects but the problem of mold, sometimes several feet thick, has still to be conquered.

It is now recognized that many other substances are attacked by fungi—electrical insulation, metal, even glass. The article on page 52 provides some pointers on designing products to avoid fungi corrosion.

—Benedict A Leerburger Jr

SIDELIGHTS

Elementary physics, you'll say, but it stopped us cold. The story goes that a truck driver was climbing a steep incline with an overloaded truck. To make the grade he reached out, every mile or so, and beat on the side of the truck with a big stick. He insisted this made all the difference since he was carrying a load of pigeons and he had to keep a good number of them in the air. They tried this one on us in college physics: Put a bottle on a scale. A bee flies into the bottle. When does the bee's weight register? Does capping the bottle make any difference?

Our statistics department just received a publication called *The World's Telephones* and extracted the following data. The US had 66,645,000 telephones in use on Jan 1, 1959. This is more than half the world total (124,800,000). We used our phones for over 82 billion conversations during 1958. This averages almost 7 uses per day per phone (two phones for each conversation). Did you do your share?

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Short-run Blanking by Rubber Die Process**
Economical method turns thin sheetmetal into complex shapes; gives runs of up to 500 parts—or models for developmental work.

. . . **Damping Tapes for Vibration Control**
Inexpensive, reliable and lightweight way to dissipate excess vibratory energy.

. . . **Measuring Cyclic Speed Variations**
Six methods, including new one offering high accuracy, relative simplicity.

. . . **Engineer Effectiveness**
Can we get more engineering per engineer? Article shows how to measure and improve effectiveness.

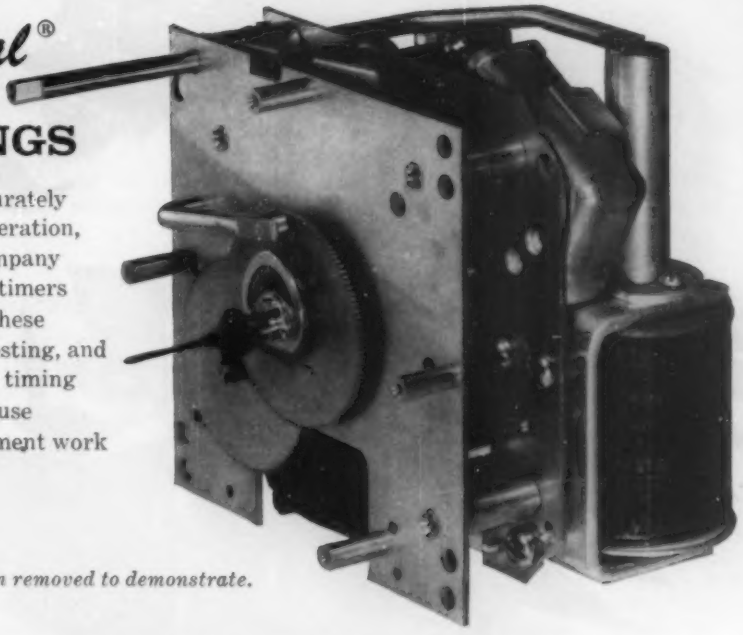
. . . **7 Ways to Limit Shaft Rotation**
Traveling nuts, clutch plates, gear fingers and pinned members are the bases of these mechanisms.

. . . **Measuring Duty Cycle of Energized Ac Winding**
This new development makes possible the determination of winding temperatures while operation of windings under actual load condition is taking place.

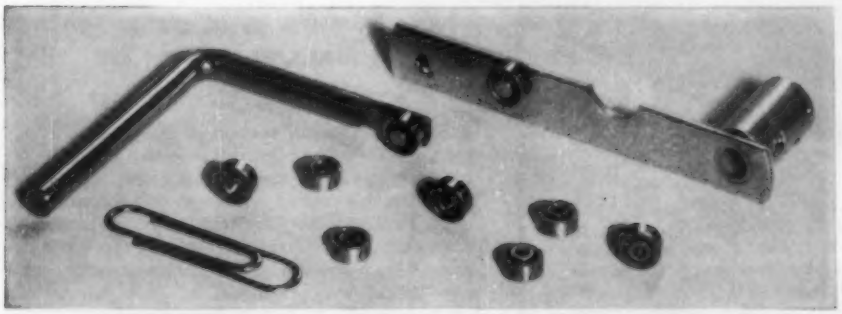
TIME AND PRECISION BEARINGS

HEIM *Unibal*® MINIATURE BALL BEARINGS

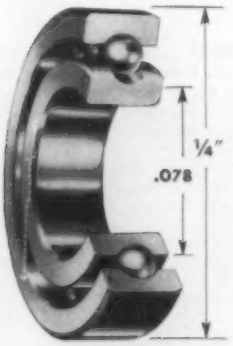
For measuring elapsed time accurately to within .001 of a second per operation, The Standard Electric Time Company manufactures precision electric timers which "split the split second". These timers are used in laboratory, testing, and production work wherever close timing is a requisite. Thousands are in use whenever research and development work must be accurately timed.



Dial and case have been removed to demonstrate.



Heart-shaped cams are attached to both hands of the timer. Miniature Heim Ball Bearings act as cam drivers, or friction-free rollers, to reset the timer after each use.



Unibal Ball Bearings Now Available in Miniature Sizes.

The simplified construction of the Heim Ball Bearing permits its assembly with just the inner and outer races and a full complement of balls. Insertion grooves, retainer rings, and spacers are eliminated.

Shown above are bearings with flush races, bearings with extended inner races for clevis mounting. The two reset arms, as used by Standard, indicate the method of mounting the bearings.

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Save money on your ball bearing requirements with Heim Unibal.

HEIM BEARINGS ARE SOLD BY THE MOST RESPONSIBLE BEARING DISTRIBUTORS IN THE U.S. AND CANADA

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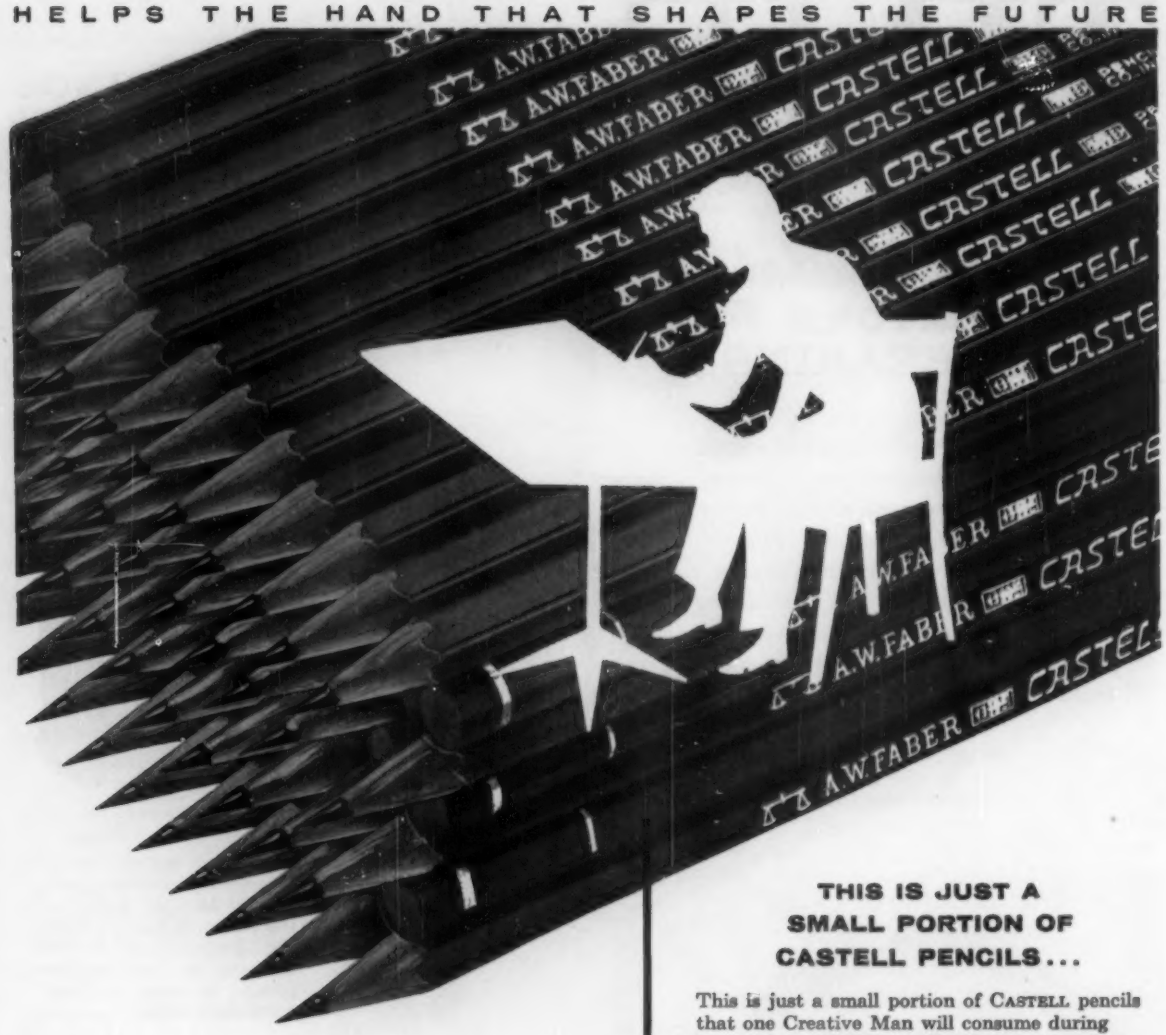

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CASTELL Pencils and Leads draw perfectly on all surfaces, including Mylar-based Polyester drafting films. Give graphite-saturated lines, easy to erase — excellent reproduction.

DEVELOPMENTS TO WATCH . . .

More indium at lower cost . . .

. . . is coming from both US and Canadian suppliers. That means new opportunities to use this low-melting (313 F), corrosion-resistant metal as a coating for bearings and other mechanical parts as well as in semiconductors (thermistors, transistors, and photoconductors), oxide-film resistors and rectifiers, and electrical-contact alloys.

Indium metal is far from cheap. Base price for the "ordinary" grade (99.9% pure) is $2.25/troy oz and electronic grade (99.999% pure) is $3.85. But new suppliers like High Purity Metals Inc (Accurate Specialties Co subsidiary) are entering the field; and ultrahigh purity metal is now available from at least one supplier (Consolidated Mining & Smelting Co of Canada Ltd) at prices about 30% below previous cost. Present range is $14.50 to $16/troy oz, and this material comes in 10-oz bars, sealed in argon in polyethylene bags.

Plastics and lubricants with improved thermal stability . . .

. . . are promised by two new chemical compounds now going into commercial production at DuPont's Repauno Works. The compounds themselves, known as PMA and PMDA, are only intermediates useful mainly in making other materials; but DuPont thinks enough of their commercial potential to plan turning out "several million pounds" a year. The intermediates have already demonstrated their ability to produce epoxy coatings that withstand 100 hr in boiling water, and lubricants that may prove useful in jet aircraft.

Thermocouples for the 1800 to 2300-F range . . .

. . . can be made with semiconductor-type materials, Ukranian researchers report.

They've been testing such combinations as molybdenum disilicide and boron carbide, and say they've developed thermal emf's in the range of 40 microvolts/degree—four times higher than that of platinum/platinum-rhodium couples.

In one design, the molybdenum disilicide forms the outer shell, while the core is boron carbide. The two are welded at one end to form a rounded tip, and wires are connected (one to each material) at the other.

This design is now under test in a steel plant, monitoring waste gases from an open hearth furnace. Glass-industry tests are also planned; and, the Ukranians say, when the thermocouple is protected by a silicon nitride or titanium nitride sheath, it is expected to be applicable to temperature measurement in aluminum electrolytic cells and for direct immersion in liquid steel.

Now under development for still higher temperature ranges, is a titanium-carbide/boron-carbide couple, expected to prove suitable up to 2300 F in non-oxidizing media.

Power requirements are reduced . . .

. . . by a new arrangement of wheels and rollers in the Szabo farm plow, its Hungarian designers claim. They say it incorporates an "entirely new principle" of operation that substantially reduces the tractive power needed.

As the photo shows, the plow has a wheel that rides on the side of the furrow, and conical rollers to guide, turn, and mix the soil.

The wheel, the Hungarians claim, transforms sliding friction of the soil into rolling friction. The rollers, which replace the conventional mold board, also help convert the sliding friction into rolling friction, again reducing tractive power requirements.

Other advantages claimed include better dispersion of the soil and a smoother surface which prevents excessive loss of moisture.

Roller-type farm plow is said to improve plowing action as well as reduce power requirements. Closeup here shows wheel and roller.

In home-appliance design, the next 10 years will see . . .

. . . miniaturized mechanical components providing more usable space in refrigerators, freezers and similar units; better insulation, and improved shelf arrangement, says B. A. Chapman, executive vice-president of Kelvinator.

But, in Chapman's view, the super-duper "electronic kitchen-of-tomorrow" is not likely to appear in the average home at any time in the near future. Even electronic cooking units are likely to remain in the luxury class for at least the next decade.

For the present, range improvements will be small (but important) ones aimed at greater ease of cleaning and simplified maintenance.

As to thermoelectric refrigeration, Chapman says, "Whether this 90-year-old principle can find application on a consumer level in the next 10 years depends on the progress of research programs now underway." He is optimistic; but is not making any promises.

The same is true of ultrasonic cleaning. Progress will be made—but how much depends on today's research programs.

An analog system for analysis of structures . . .

. . . subjected to shock and vibratory loads is being developed at Naval Research Lab. It's based on mechanical impedance which, NRL researchers say, is a direct analog of electrical impedance.

A report on the first phase of the work, defining the reference system and presenting electrical-circuit theorems which seem especially applicable to mechanical systems, is being prepared by R. O. Belsheim and J. W. Young Jr of NRL and is to be made available through OTS, Dept of Commerce, Washington 25, DC as PB 161022.

Better electrical steels are needed . . .

. . . for rotor and stator cores, the Navy says. Tests of open submersible motors (*PE—June 8, p 45*) under intermittent and continuous operation show insulation performs admirably and bearings present only minor operating difficulties. But the electrical sheet steels used for rotor and stator cores are far from satisfactory.

Corrosion is the most serious problem. A study of available materials, says Navy's Bureau of Ships, indicates "none of those tested . . . are suitable for use in this type of motor."

Though the hunt for better steels is continuing, the Bureau's current research program concentrates on developing a protective coating for the cores that will provide the required protection.

Physical properties of fibers can be changed . . .

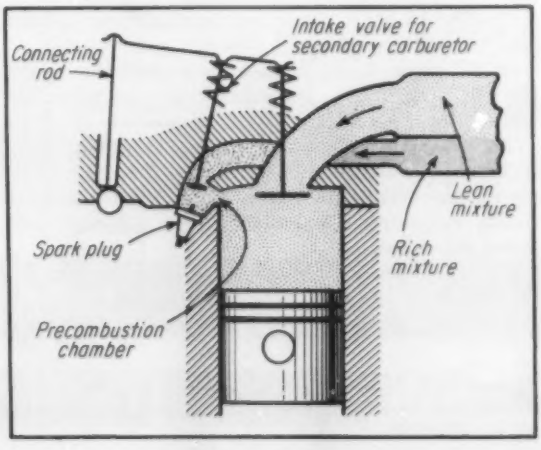
. . . by electrical glow-discharge treatments, say USDA researchers. The glow stiffens the fibers somewhat and seems to roughen their surface, but it also increases their strength by as much as 20%.

For the tests—primarily on cotton—USDA is using gas-filled tubes through which a weak electrical current (10 to 50 ma at 1000 v) is fed. Tests are continuing further to explore the effects and their causes.

Fuel consumption is reduced 20% . . .

. . . by a dual-carburetor system developed in Russia, says a Czech weekly. Original aim was an engine for cold climates where diesels are hard to start—and the new design is said to "exceed even the diesel in economy."

To the regular carburetor it adds a second one with its own manifold and intake valve. This secondary, fitted to the cylinder head, is modified to form a preignition chamber, similar to that of a diesel engine. As the diagram shows, the sparkplug is located near the intake valve of the secondary carburetor, which carries a rich mixture. The primary carburetor is adjusted to carry a lean mixture —too lean for direct ignition by the sparkplug, but set off in the main chamber by the rich mixture. —ARG



Dual carburetors and new preignition chambers are said to be keys to savings with this Soviet engine.

WHAT'S HAPPENING IN RESEARCH . . .

Better instruments needed

If you've found the "best" pressure transducers, environmental testers, timers, and high-temperature measuring systems none too good, you are not alone. Instruments rate high on the National Inventors Council lists of needed inventions (*PE*—Apr 20 '59, *p* 52; Nov 2 '59, p 43), and among the most needed are such broadly useful devices as:

- An electronic timer to measure time intervals, 0.1 microsecond to 0.999,999,9 seconds, to an accuracy of ±0.01 microsecond or better.
- A temperature-measuring device for accurately determining translational temperature of gases or plasmas in the region 5000 K to 20,000 K.
- Pressure transducers for the range 0.1 to 1000 mb with an electrical output (preferably resistance) which employs no moving parts such as diaphragms, linkages nor liquids (hypsometers). The NIC is also looking for transducers capable of operating with ambient temperatures on the order of 3500 F at the transducer diaphragm; and able to withstand repeated cycling to a force of 50 g's with less than a 1% detriment on the data produced.

Fibers that pipe atom light

A fiber scintillator that uses ultrafine strands of plastic fibers to transmit light produced by ionizing particles is announced by the USSR Joint Institute of Nuclear Research. It shows the Soviets, like UK and US scientists, are exploring the possibilities of "fiber optics" (*PE*—May 5 '58, *p* 6).

In this particular application, the fiber bundle abuts directly on the amplifier; and, say the Soviet researchers, "because only those fibers scintillate through which ionizing particles pass, the path of the particles can be recorded with considerable precision." Three-dimensional determinations can even be made by using alternating bundles of fibers perpendicular to each other.

One important point: The type of plastic and its processing are extremely important in obtaining good scintillation. The Soviets are using a polystyrene resin containing 1% tetraphenylbutadiene, and polymerizing as rapidly as possible.

Naming the big ones and the micros

The International Committee's recommendations on prefixes for big and small numbers have now been officially adopted by the National Bureau of Standards. Here, for ready reference, is a rundown:

Symbol	Prefix	Number
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
h	hecto	10^{2}
dk	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}

Meet a rare one

The world's largest supply of one of the world's rarest elements, protactinium, is in hands of the United Kingdom Atomic Energy Authority—and it's planning to share it with us.

This radioactive metal (number 91 in the Periodic Table; symbol: Pa) is so scarce that there are no reliable figures on abundance; and it has been exceedingly difficult to isolate even the small quantity that is available from the uranium ores in which it is found. The British, however, have a new separation process that has made it possible to obtain about 100 gm of the metal, and a start can be made on outlining its properties.

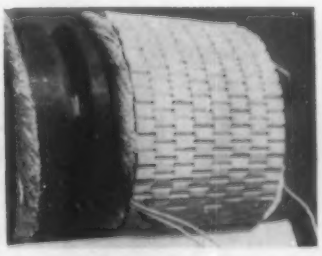
So little of this metal has been separated until now that data on its properties is hard to find and often confusing. Published figures on melting point, for instance, range from 3400 to 5400 F. It does, however, appear to be a fairly heavy material (density is between that of mercury and tantalum); and it is known to have at least a dozen isotopes, some with a very high neutron cross-section, and others rather low.

The price, incidentally, puts gold, platinum, and uranium to shame. Protactinium is $2800/gm.

Also coming up from UKAEA—additional supplies of technetium (element 43). UKAEA is recovering it from reactor waste materials by a nitric acid ion-exchange process, now has 20 gm on hand. This element, never found in nature, is available only through processing reactor wastes; and, says UKAEA, it takes about 6 tons of waste to produce one gram of technetium. —ARG

Flexible heat from Britain

Tailor-made-furnace, designed in England, features flexible blanket of ceramic (95% alumina) beads that can be applied to radii as small as one inch, and will stand loads to 450 psi. Beads are interlaced with nickel-alloy resistance wire which is the heat source. Top operating temperature is 1832 F. Nominal-rating is 25w per sq in.. Electrothermal Engineering Ltd, 270 Neville Road, London 7, makes it.



AN UNBEATABLE

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(CARBON-GRAPHITE)

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GRAPHITAR is being used successfully not only in seals, but in such diverse applications as packing rings, clutch release bearings, fluid coupling seals, piston rings, sump pump bearings and more recently, in the nuclear and rocket-missile field as moderators, reflectors, fuel jackets, vanes and motor linings.

GRAPHITAR can be utilized to advantage in almost every industry. Perhaps you can put GRAPHITAR . . . the versatile engineering material . . . to work for you.

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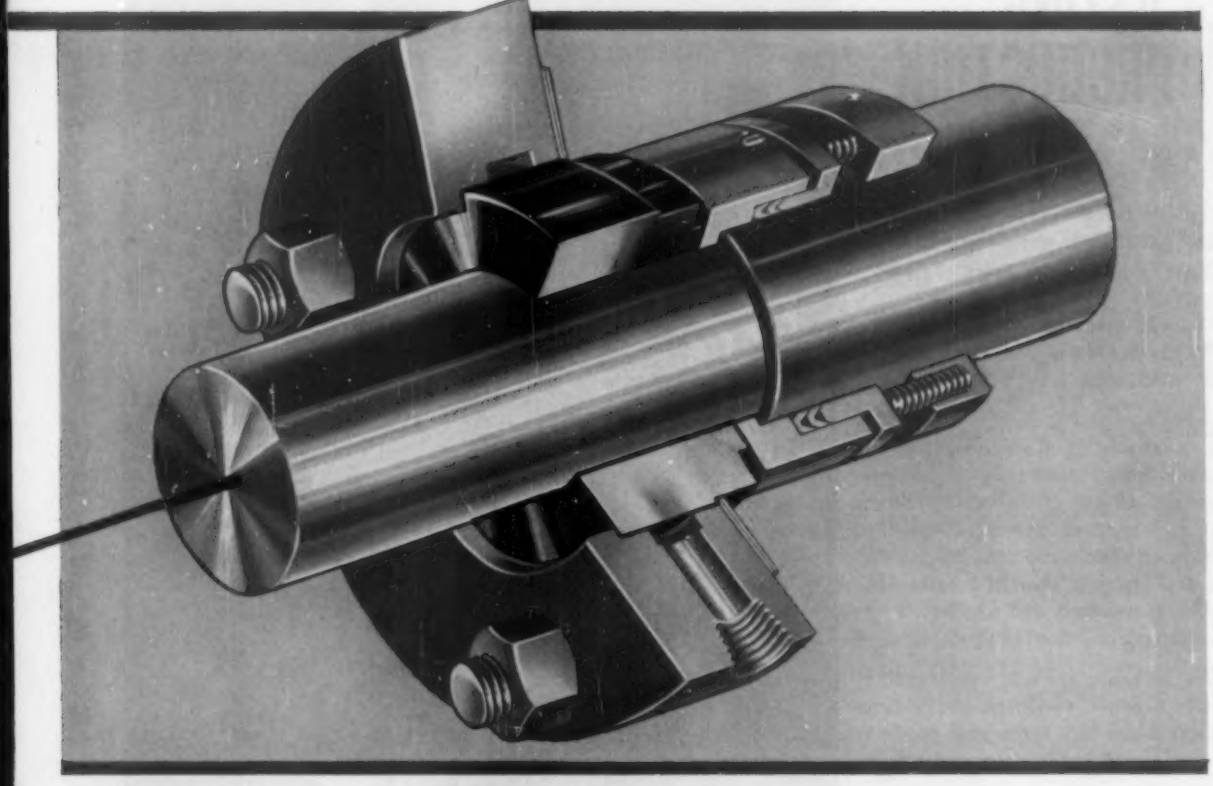
COMBINATION!

mechanical seal with engineering material



BULLETIN NO. 20 gives complete engineering facts on GRAPHITAR. Write for your free copy.

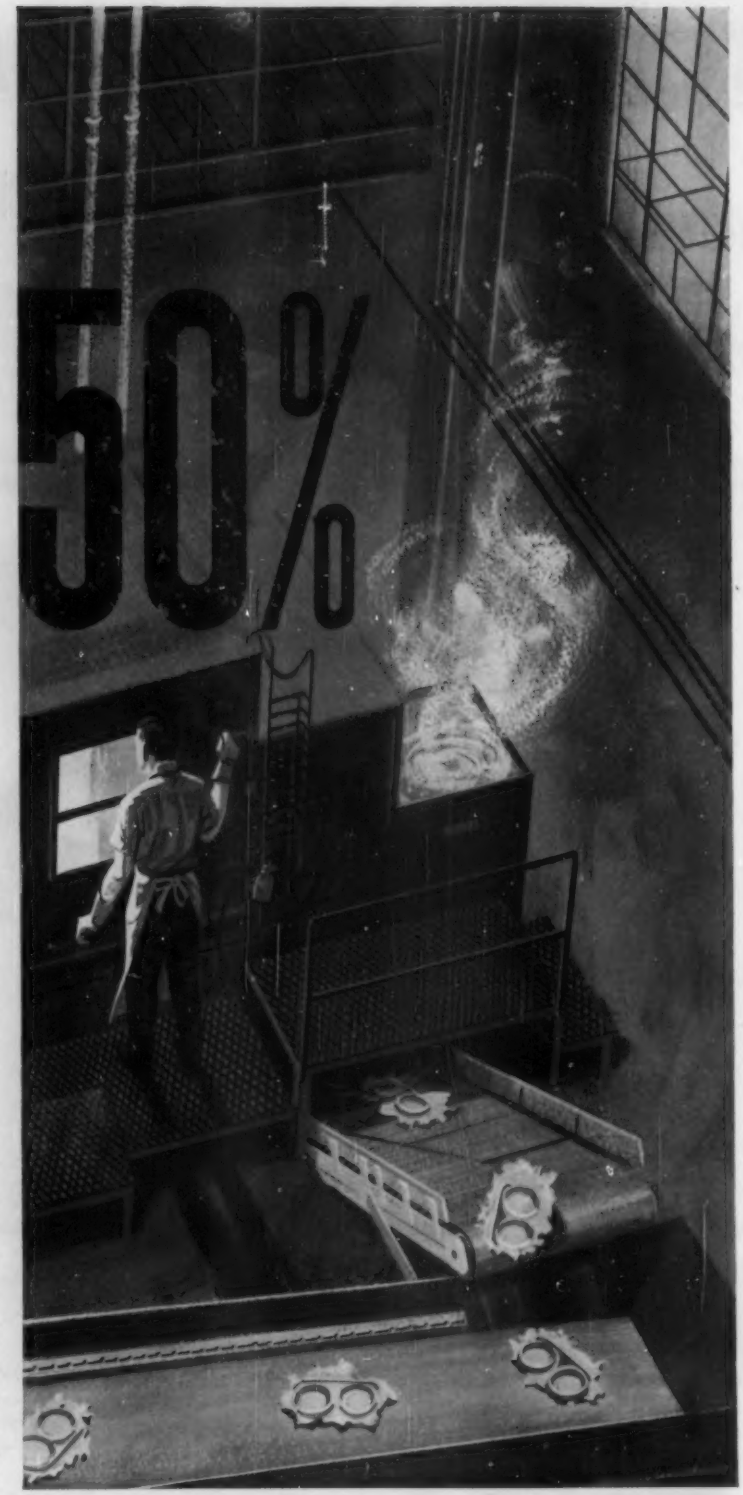
R-281-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

MODERN DROP-THROUGH METHOD SPEEDS DIE-CASTING PRODUCTION BY 50%

Brown-Lipe-Chapin eliminates manual handling with mechanical ejection of hot die castings.



Here's a typical example of how Brown-Lipe-Chapin engineers put quality into your die cast parts.

After the die casting cycle, castings are ejected automatically into a quench, where a conveyor takes them to the trim press. This modern method of die casting allows a maximum operating rate and boosts the over-all production rate by 50%. Also, casting uniformity is assured because the cycle time is constant and unaffected by operator fatigue or other human factors.

This is just one of the many outstanding features of Brown-Lipe-Chapin die casting facilities that can help make your product better and to more rigid quality standards.

Under the same roof are facilities for metal stamping, anodizing, electroplating, buffing and polishing, precision painting, plus complete engineering service. And two Brown-Lipe-Chapin plants, strategically located in Elyria, Ohio and Syracuse, New York, offer the same complete facilities. For further information, call or write Brown-Lipe-Chapin, Syracuse, New York.

GM GENERAL MOTORS

RELIABILITY by BROWN·LIPE·CHAPIN

DIVISION OF GENERAL MOTORS CORPORATION

FROM WASHINGTON . . .

Watch for Congress to attack the Administration's defense policies

Politics will be the prime reason. As the election year shapes up, Democrats are seeking campaign issues to hammer at the Eisenhower Administration. And the party leaders see defense and space as fertile fields to exploit.

US lag in space exploration will be blasted by both House and Senate committees. The congressional critics have two main objectives: stronger centralized control over the military and space programs, and a big boost in spending on the total effort. Failure of the US to make any spectacular achievements in space efforts during the past year makes the program ripe for attack.

The Administration will likely hold congressional efforts to boost spending on space programs to only token amounts. But the legislators may push through more unified controls. The recent hassle over building engines with million-pound-plus thrust makes a good arguing point for better coordination between the defense and civilian space administration.

Congress will drive for stronger military unification—possibly even a merger of the three services. The Administration will fight this hard, however. Such issues as better military procurement policies, with small business getting a bigger chunk of the defense dollar, will be pushed. A hot issue for years, it is always revived during election years. Profit allowances, contracting practices and the renegotiation system will be played up.

Individual military leaders will get congressional encouragement to air their gripes against present policies. This is one of the few times the military can speak out openly without being accused of bolting the team. It is a politically fertile field that Congress won't pass up. **Few basic changes, however, are expected to be legislated.**

Don't look for any major relaxing of trade barriers with the Soviets

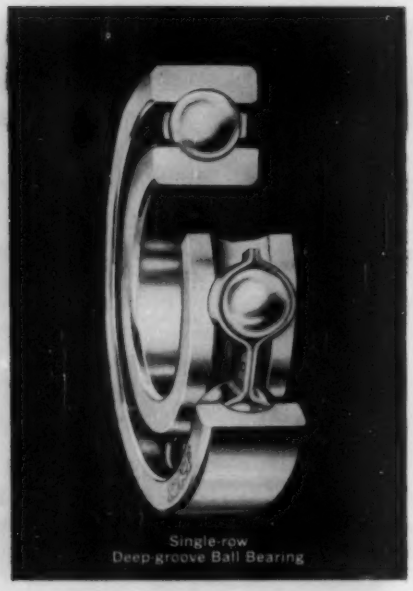
Although the US recently okayed the $30-million sale of a textile spinning and weaving plant, a change in policy is not imminent.

Strategic items and advanced technological processes and patents will still be denied export to Russia. In fact, the textile plant, sold by Intertex International Inc, doesn't include the latest technological developments in this field.

Government crackdown on packaging industry possible

A government crackdown on the packaging industry may bar many commonly used materials for packaging food. In 1958, the Food Additives Amendment gave the packaging industry until March 5, 1960 to prove that chemicals used in its products don't harm food. The industry is now plugging for a blanket one-year extension on grounds that it hasn't had time to perform the necessary laboratory tests. Secy. of Health, Education and Welfare Arthur S. Flemming, however, is reportedly cool to the idea, will likely make individual company extensions instead.

Products that are in most danger of being yanked off the market include types of paper and plastic wrappings. Sulfides, defoamers and chemicals used to keep paper-making equipment clean find their way into the product and possibly into the food. Many of these wrappings have not been extensively tested as yet and may be barred from use until tests are completed.



Can a standard bearing offer you "more bearing" for your money?

It can if it's made by SKF—because all SKF bearings, both ball and roller, offer special qualities at "production" bearing prices.

Take the single-row deep-groove ball bearing featured here, as an example. SKF designs and builds this type to sustain heavy radial load and thrust load in either direction. Furthermore, it is engineered to run smoothly and quietly at normal speeds with grease lubrication—and at high speeds with oil.

Yet this is a standard SKF ball bearing, mass-produced by automated production equipment at our plant at Altoona, Pa. You can quickly get this bearing in over 100 sizes, ranging from 5/8" to 15.748" O.D., and in a variety of seal, shield and snap-ring combinations.

But why not find out what SKF offers in bearing quality, availability and economy? Just call the SKF branch office nearest you.

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THE ENGINEERING WEEK

Martin's Troublesome Missile: Candid Countdown on the Titan

CAPE CANAVERAL, FLA.—It's a dramatic switch—like a football coach replacing the quarterback—when a corporation sends its board chairman in to take personal charge of a big but faltering engineering program.

Such was the move that has placed George M. Bunker, chairman of the board of The Martin Co, in complete and direct control of the company's Titan missile program. And it indicates that problems with the Titan ICBM have been more procedural than of the faulty-engineering type. Strengthening this explanation for Martin's move is a close look at the Titan failures to date.

The record shows 15 of these missiles, which were intended to surpass the present operational Atlas, have gone through three series of firings, with one more to go. Of the 15, only 4 were successful.

Missile experts point out that all the static firings went off okay—one more indication the Martin's engineering has no basic flaws . . . that most of the grief has come from need for tighter procedural control. This is believed to be the reason why Bunker's taking over full charge coincides with the decision to coordinate all Titan engineering and production at Denver.

Here's the scoreboard for the six firings in series A, seven in series B, and two in series C.

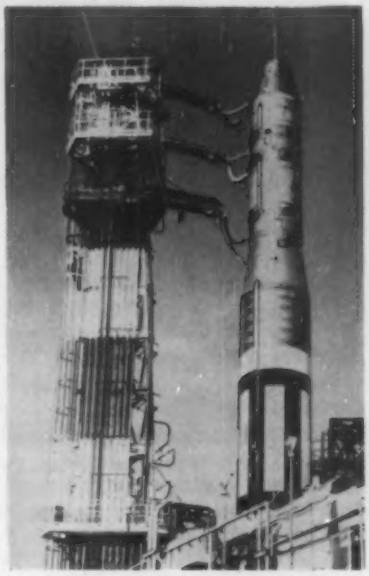
- A1—OK. Static missile for stand checkout; showed no basic engineering flaw.
- A2—Goof. Erector tower pulled off the second stage.
- A3—OK. Required rework at Martin's Denver facility before flight but first-stage successfully fired.
- A4—OK. After rework, successful first-stage firing.
- A5—OK. Successful first-stage firing.
- A6—OK. Successful first-stage firing after rework by Martin.
- B2—Goof. Static missile damaged when sling broke in Denver.
- B4—Goof. First stage blew up when Lox tank ruptured—caused by not following procedure (filling tank too rapidly).
- B5—Failed. Blew up at Canaveral when sequencer signaled cutoff of engines after premature lift-off had begun.
- B6—Goof. Helium line at Canaveral tore loose, putting hole in first stage.
- B7—Goof. Helium sphere tore loose in tank at Denver; support leg put hole in second stage.
- B8—Goof. Failure to open valve in the Denver-Canaveral airlift resulted in pressure differential and cracked tank.
- B9—Failure. Loading of Lox into cool tank at Canaveral resulted in negative pressure, causing tank to "suck-in" and crack. This condition never encountered before. Later duplicated in Denver and the information disseminated to industry.
- C1—OK. Static-fired in Denver. Now in use for tests on destruct package.
- C2—Failure. Blew up at Cape Canaveral Dec 12 '59 when destruct package inadvertantly exploded. Unknown whether this was due to severe shaking in pre-launch, engine run-up phase or if signal set off explosion. There has been criticism that Martin is overloading the Titan with extra safety equipment which may be causing failures by improper functioning.

And that's the record according to reliable sources.

RIVALS HAD PROBLEMS TOO

The aims of Titan, according to the Pentagon, are for an ICBM that will go further and faster than the present operational Atlas. The Atlas is rated at 7000-mi range and speeds of 16,000 mph. The Titan is geared for 9000 mi and speeds in excess of 17,000 mph.

The reasoning behind this is that faster reentry lessens the chance of countermeasures by the enemy. On the drawing board is a super-Titan capable of placing a thermonuclear warhead a distance of 10,000 mi. This is presently the ultimate military requirement for an ICBM.



Unlike the problems faced by Convair's Atlas throughout the middle of 1959 and Douglas Aircraft's Thor a year earlier, Martin is faced with a problem here, a difficulty there.

Atlas and Convair went through a period of five straight failures (*PE*—Aug 31 '59, p 20). But telemetry each time pinpointed the cause and area with more certainty than the preceding failure. A new valve was designed and tested, and Atlas has scored 14 successful flight tests.

—Douglas Dederer

Scientist Sounds Call for Women in Labs

CHICAGO—At a time when the extent and quality of our scientific manpower resources are critically important, we are failing to exploit the potentials of women for scientific research and teaching. This warning by Dr Alan T. Waterman of the National Science Foundation was given to the annual convention of the American Association for the Advancement of Science.

Although more girls than boys—both numerically and proportionately

—are graduated from high school, he said, fewer go on to college. He offered figures showing that the loss is particularly acute among high-ability girls. Less than half the upper 30% of able girls continue their educations, compared with 60% of boys. And as the education process continues into graduate levels, the rate of attrition grows steadily.

Dr Waterman attributed the limited number of women in science to three interrelated causes: prevailing social and cultural attitudes; discriminatory hiring practices; the difficulties of combining career with home.

In our society, he suggested, boys are expected to display mechanical interests; girls, interest in domestic arts. Too often, natural curosities are repressed first at home and later in elementary school. In highschool, he urged, career advisors should make young women more aware of opportunities in science and in college of graduate assistance available through fellowships such as those offered by NSF.

"We are still in the midst of an evolving social pattern in which women are striving to assert their rights," Dr Waterman declared.

"It is only a matter of time until women come into their own in science as well as other fields. Science, itself, freely acknowledges women's ability to do so. It finds no inherent differences between intellectual capabilities of men and women."

Many women have achieved distinction in science in spite of obstacles, Dr Waterman concluded: "It should be fairly clear by now that whenever women have firmly fixed their eyes on a goal and set their minds to achieving it, no barriers can hold out for long. If women have looked upon the fields of science and found them fertile and interesting, men should give them wholehearted support." ■

Demand Surges for Engineer Grads But Still No Gravy Train

NEW YORK—Twice as many engineers were hired from graduating classes during 1959 as during the year before and the upsurge is expected to continue. Yet . . . an engineering degree is no longer open sesame to a high-paying job in industry. These conclusions are based on reports issued recently by two agencies close to the engineer-employment picture — Engineers Joint Council and Cornell Univ's College of Engineering.

BOOMING DEMAND FOR ENGINEERS

A surge in the demand for engineers last year led to more intense recruiting by industry. In its annual survey of demands for engineers, EJC found that net increase in the number of engineers employed by industry was double that of 1958. And it would have been higher if more technical talent had been available.

The opening for engineers last year were about on par with 1956-57, the EJC found. But the acute deficiencies of that earlier year were not evident except in certain weapons engineering areas. The reason was that schools graduated the largest class of engineers since 1951 and about 41% more than they did in 1955. This considerably enlarged the immediate supply of engineers available for employment.

Assuming continued economic growth and stabilized government expenditures, demand for engineers will rise substantially in the year immediately ahead the EJC predicts. College enrollments declined both in 1958 and 1959. But industry now expects to need 15% more engineers in 1960; 17% in 1963; and 21% in 1966. If present enrollment trend persists, companies will have 15 openings for every 10 graduates in 1966.

Last year the largest deficiencies showed in aircraft, electrical equipment, electronics, R & D and telecommunications. In certain industries some companies reported fewer engineers. These included construction, rubber, fabricated metals, railroads and consulting services.

The EJC also found increased emphasis last year on quality and advanced degrees. Turnover averaged 8.6% of total engineering employment compared with 11% in 1957 (*PE—Nov 2, '59, p 28*). Starting salaries reached a new high, with a monthly median of $510. In electrical equipment and electronics, median was $523 and in aircraft $526.

MORE PICKINGS BUT LEANER

An engineering degree is no longer a passport for college graduates to executive-sized jobs and salaries, according to Donald H. Moyer, director of the Office of Student Personnel, College of Engineering, Cornell Univ.

Ground Transport for Rocket Engines

This 80-ton mobile Transrector can handle rocket-engine units measuring up to 35 ft long, 85 in. dia and weighing up to 80,000 lb. The vehicle (basically a tractor with a special trailer) is a combination of hydraulically actuated mechanisms and electric hoists. Special controls enable it to respond instantaneously when positioning engines either horizontally or vertically in test pits for static firing.

One reason is the intense competition for engineering graduates which developed during recent years caused many companies to train liberal-arts graduates to fill jobs previously held by engineers.

Also, Moyer says, companies have hired technicians to fill such positions. Result is a selective demand for high quality engineers, which began in 1958. This was a year of recession, Moyer points out, when work slowdowns and layoffs resulted in industry retaining only high calibre men.

He feels that the recent belt-tightening in employment policy by industries may result in an even more competitive atmosphere at engineering colleges. Companies are placing more and more emphasis on the quality of training, he said: "Again this year, men in the top half of the class will have few if any placement problems. The below-average student will get a job, but it may not be exactly the job he wants, or where he wants it, and he may have to take the initiative."

An alternate outlook appears, however, when evaluating our present and future business trends. Moyer says an accelerated economic expansion program could again shoot the demand for engineers sky-high, and if this country's business recovery is at all above average, the lucrative offerings to graduating engineers will once again occur. ■

Rocket with a Throttle

Described as the world's largest known variable-thrust rocket engine, this Aerojet-General Corp liquid-fuel rocket is capable of giving stable operation from 50,000 to 150,000 lb of thrust.

THREE STEPS COVERED BY NEW SCRIBING METHOD for preparing printed-circuit layouts are (1) master outline of circuit elements, (2) the peelcoat or intermediate negative, and (3) the final master print—twice the size of the actual printed-circuit board. System was developed by General Electric Co's Heavy Military Electronics Dept in conjunction with Keuffel and Esser Co, Hoboken, NJ.

Three-step Methods Speeds Printed-circuit Preparation

SYRACUSE—A new method of preparing printed-circuit layouts, reportedly 100% faster than conventional inking-and-taping methods, has been developed by General Electric Co's Heavy Military Electronics Dept. The technique is said to eliminate opaquing, and be especially suited to jobs requiring irregular shapes, long runs and complex steps to isolate high-frequency leads.

HOW IT WORKS

Standard circuitry is first outlined on a translucent "scribecoat." Then a photographically sensitive film is exposed to this master outline, producing a line image on the emulsion layer of the sheet. Area between each translucent line, not the line itself, is the circuit path desired.

In the developer, image lines are eaten away down to the "peelcoat" layer. The sheet is then wiped with an alcohol-dampened cloth, further dissolving the image lines through the peelcoat and down to the film base. Valleys, two layers deep, result. Emulsion layer of the sheet is then washed away leaving valleys in the peelcoat only. Finally the coating between each translucent line is peeled away, leaving finished circuit-paths. This final master and file copy can be further reprinted.

GE's system insured accuracy in three ways:

(1) Points, made of steel alloys, have graduated widths and cut extremely sharp, precise lines. Use of constant-width scribe points, in turn, eliminates minute variations in circuit-line widths—common to pen-and-ink work where amount of ink in a pen can alter the line thickness and clarity.

(2) The film on which the scribing is done contains grid lines for accurate positioning of the board element. The film, called Stabilene, was developed by Keuffel and Esser Co, Hoboken, NJ. It is a re-stabilized, polyester-based material that maintains constant line character under extreme temperature and atmospheric conditions.

(3) The scribing tools, devised by GE engineers, are equipped with unique spring-type shock absorbers.

They maintain the same accuracy on curved as on straight lines, eliminating ragged circuit-paths. Unlike ordinary scribers or drawing instruments, the GE devices "outline" a circuit line. Thus two extremely accurate, separated lines are scribed into the film to outline what will later be a solid line.

Use of specially formulated fluids permits making drawing changes during any one of the three steps: original scribed layout; peelcoat negative; and final layout.

An additional advantage is that the printed-circuit masters can be made in either positive or negative form, depending on which surface is to be stripped off. ■

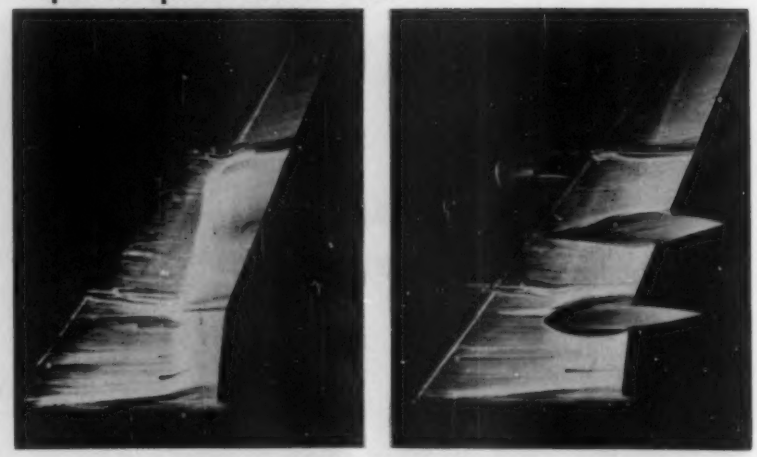
Engineers Spurn Pay of Government Jobs

WASHINGTON — The government's need for engineers, scientists and technicians will increase 25% by 1963 over 1958, but the number of engineers and scientists who reject federal jobs is going up. Chairman Roger W. Jones of the Civil Service Commission told a congressional committee that the reason is lower salaries than industry pays.

Industry paid an average of $5600 for BS graduates, compared with the government rate of $4490 for average graduates and $5430 for superior degree-holders. A year later, June 1959, industry average jumped to $5800 to $6200 while the government rate remained static. Jones predicted an industry increase in 1960 of 2 to 4%; government increase, none contemplated. But these trends, Jones said, may explain recent reports that the government will return to the use of "highest step in grade" authority for engineering positions.

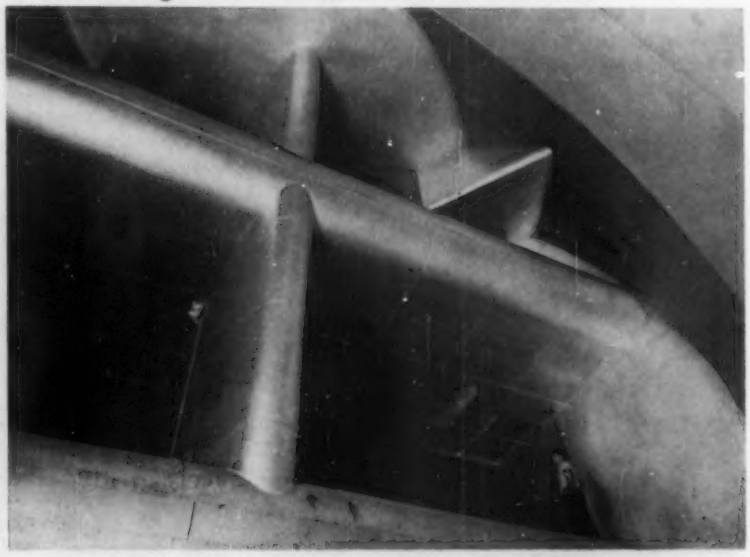
To meet the recruitment problem, Jones urged Congress to adopt a revised-classification pay plan with strong emphasis on flexibility. A new pay schedule plan is under advisement, it is reported, that would provide minimum and maximum salaries in some salary ranges. Within these groups, the Executive Branch could place employes at appropriate levels to reflect private competitive rates, geographical salary differences, individualized special ability, and higher rates for shortage occupations. ■

Capsules Speed Convair 600



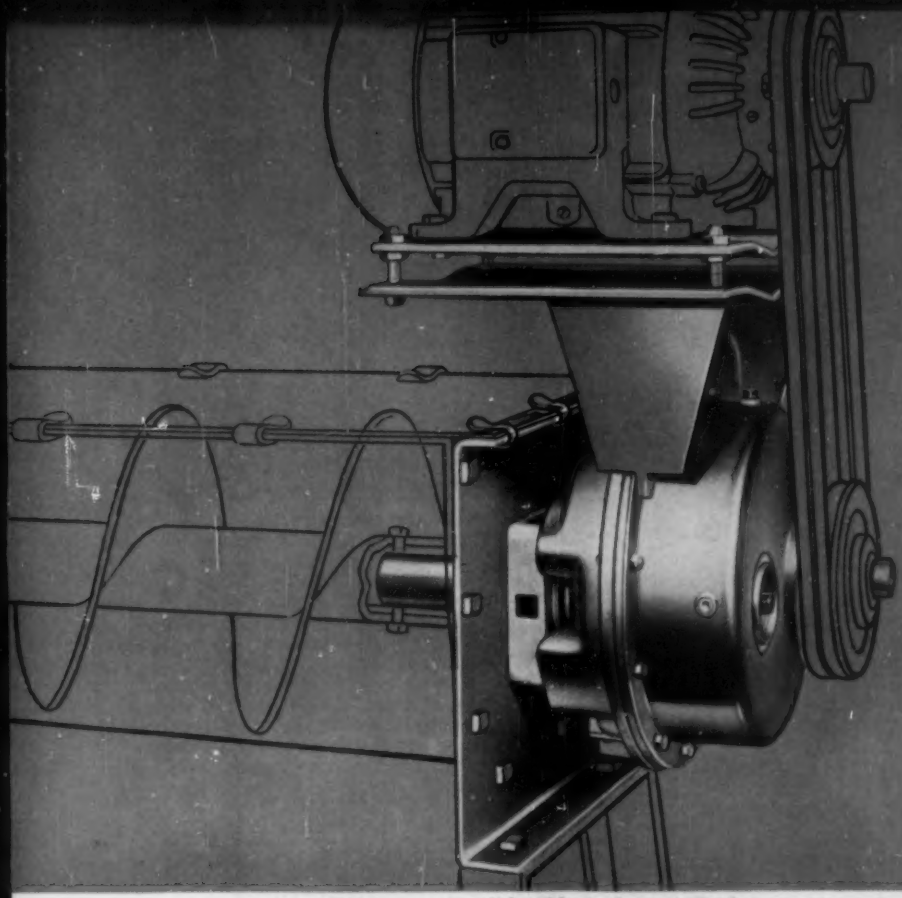
Aerodynamic antishock bodies resembling upside-down canoes are attached in pairs to the upper surfaces of each of the swept wings of a Convair 600. Since the Convair 600 flies at subsonic speeds (Mach 0.91) considerable shock wave is built up on the wing (left) but use of the capsules smooths the airflow (right), eliminating shock wave and its resultant drag. The two inboard capsules measure 22 ft, 10 in. long, and 40 in. at widest dia. Each holds about 300 gal. of fuel and extends 7½ ft behind wing's trailing edge. The two outboard capsules are 24½ ft long and 51 in. across at widest dia; extends 11 ft behind wing's trailing edge and hold approximately 218 gal. of fuel each.

World's Largest Air-Blower Feeds this Tunnel



Huge propulsion wind tunnel being built at the Air Force's Arnold Engineering Development Center, Tullahoma, Tenn, is powered by world's largest rotating machine. Built by Westinghouse, the machine is 480 ft long, develops 216,000 hp and is being equipped with world's two most powerful synchronous motors, each rated at 83,000 hp, and two smaller "starting" motors rated at 25,000 hp each. The four motors are connected in tandem to drive two big compressors—a 3-stage unit for the already operating transonic circuit, and an 18-stage unit for the still-incomplete supersonic circuit. Behind the grille in photo above are coolers through which more than 65,000 gal. per min. of cooling water will be pumped to absorb heat from the air in the tunnel. Compressors will drive air through the test section at velocities of 1000 to about 3000 mph. Project is under supervision of Air Force's Research and Development Command.

CIRCLE 19 ON READER SERVICE CARD→



NEW! FALK Screw Conveyor Drive

U.S. and Foreign Patents Applied For

—the drive our customers asked for

Our customers helped us design this new unit. We sent our men into the field to find out what our customers needed in a screw conveyor drive—then our engineers designed a new drive that offers the maximum of service, versatility, operating economy and long life. Here are some of its outstanding features:

A COMPLETE DRIVE: Saves engineering and assembly time. Six sizes to cover entire range—each with these ratios: — 4:1, 9:1, 14:1 and 24:1. Bolts to any standard trough end—eliminates trough end bearing. Eliminates drive shaft wobble. Efficient FALK single helical gears.

SEAL HOUSINGS: Choice of seals (neoprene or leather lip, felt or waste) to accommodate material conveyed. Space between trough seal and unit seal prevents conveyed material from reaching unit seal.

REMOVABLE DRIVE SHAFT: Snap ring assembly permits easy removal. Five sizes, from 1½″ to 3 7/16″.

TROUGH END: Can be fastened to any standard trough. Eight sizes, from 6″ to 20″.

ALL-STEEL MOTOR MOUNT: Saves costly engineering and installation time and costs; no motor plates to design or fabricate. Motor can be mounted in virtually any position. Pre-drilled to accommodate NEMA standard motors ½ to 30 HP.

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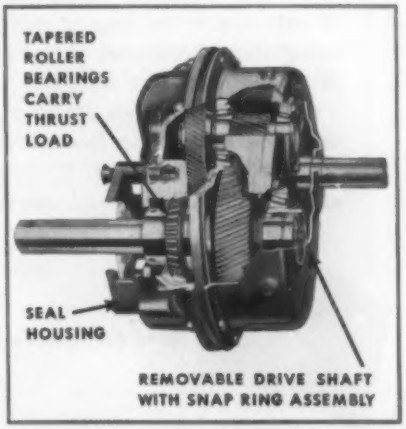

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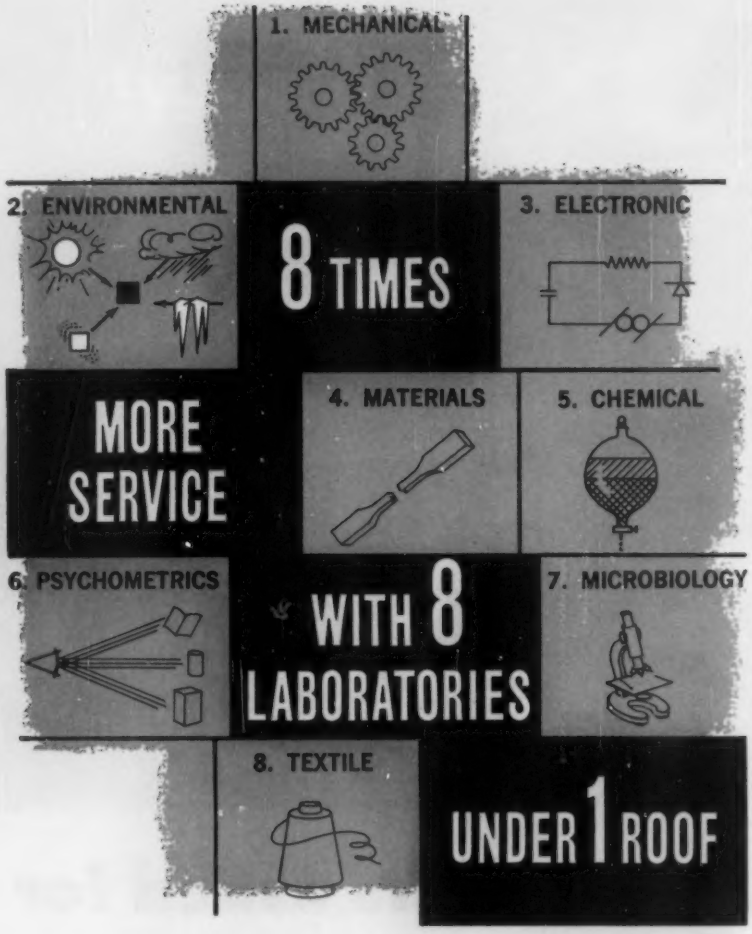

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Out-size Fork Truck

This 17-ton-capacity lift truck, developed by R G LeTourneau Inc, is equipped with three wheels; electric motors are geared to the two front wheels while the rear wheel is used only for stability and steering. Forks of the "FT Stacker" are 5 ft long and can hoist 16 ft above ground. Truck is powered by a 195-hp diesel engine driving ac and dc generators. LeTourneau engineers report that the truck can handle a variety of materials ranging from steel products to prestressed concrete.

Computers to Speed Patent-searching

WASHINGTON—The tedious job of patent-searching is being mechanized. Now under test at the US Patent Office is a speedup method borrowed from the business world—a general-purpose electronic computer that processes data cards turned out by a punched-card machine. Officials say it may accomplish in 30 minutes a job that normally takes a skilled researcher up to a full 24 hr. The system is being tested first on patent data covering chemical compounds that form many commonly used plastics.

Engineers of the Patent Office initiated the system with a punched-card device called Interrelated Logic Accumulating Scanner (ILAS) created according to special needs of patent-searching. Engineers of DuPont's Textile Fibers Dept Research Div then adapted and expanded the Patent Office punched-card system by transcribing data from selected cards to magnetic tape for use on a Bendix G-15 digital computer.

Besides time-saving, Patent Office officials expect the system to offer these advantages:

- Maintain a permanent record on magnetic tape of the areas on in-

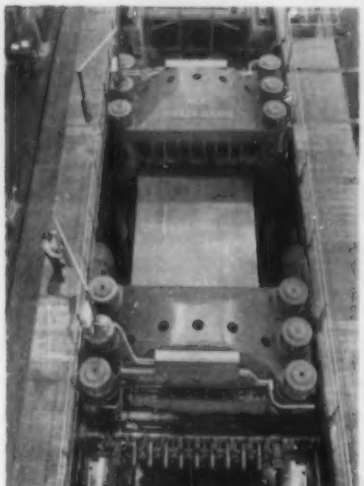
vention or discovery already mechanized; is therefore readily available for subsequent searches.

• While searching for specific patents, the computer identifies areas of invention or discovery that may have been overlooked. For instance, in searching for patented chemical compounds capable of performing a certain job, the machine may also be instructed to indicate those compounds, with similar characteristics, that might perform the same job. This gives searchers a list of alternate materials that lab research may prove to be cheaper or otherwise more acceptable for manufacturing a product.

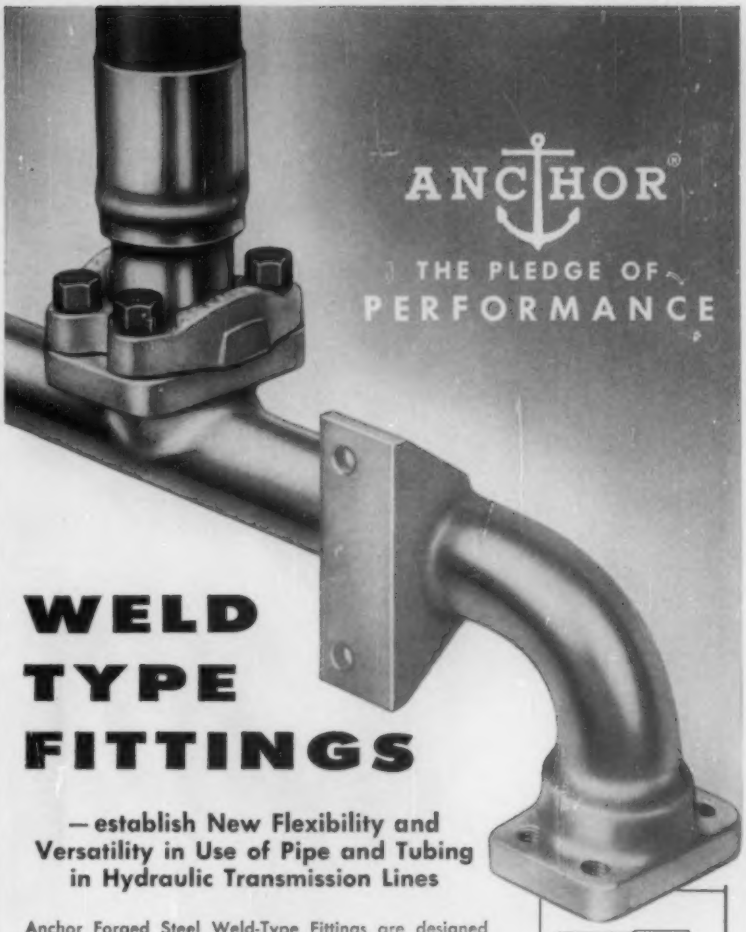
• Magnetic tapes contain complete Patent Office files on certain subjects could be purchased for use on machines the searcher owns or rents. In this way, several searchers could search identical files at the same time.

Since plastics is considered the most difficult field for patent searching, success of the new system in plastics would seem to insure its acceptance for other, less complex fields. ■

One-way Stretch



This massive machine is capable of gripping the ends of a plate of high-strength aluminum alloy 60 ft long and 6 in. thick, then stretching it by some 4 ft. Stretching refines the internal structure of the metal by equalizing stress distribution. The stretcher can handle plate 13.3 ft wide. It was built for Kaiser Aluminum & Chemical Corp by Hydraulik GMBH of Duisburg, Germany. Cross-sectional-area limit of this machine is 640 sq in. as compared with the previous industry maximum of about 350 sq. in. Operator at left controls the equipment.



WELD TYPE FITTINGS

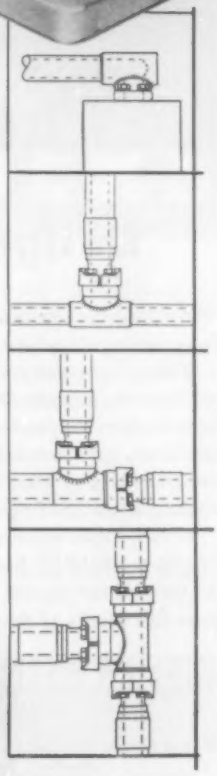
— establish New Flexibility and Versatility in Use of Pipe and Tubing in Hydraulic Transmission Lines

Anchor Forged Steel Weld-Type Fittings are designed especially for use with Anchor Split-Flange Clamp Halves and "O" Ring Flanged Head Couplings to create another Anchor Hydraulic "First."

They provide pipe and tubing assemblies with better flow characteristics. The need for pipe threads and pipe fittings, and their inherent problems, is eliminated.

Installation is extremely simple and dependable — Anchor Weld-Type Fittings are bolted securely to flange or port by four socket-head screws and an "O" Ring is employed to ensure a positive, leak-proof connection.

Anchor Weld-Type Fittings are available with drilled holes and "O" Ring Groove for bolting to valve or pump, or threaded holes without "O" Ring Groove for connection to Anchor Flanco Hose Assemblies by means of Anchor SAE 4-Bolt Split Flange Clamps. They are designed in straight, 90° elbow and tee styles for ends of pipe or tubing, and in saddle style for side positioning,— any number may be placed along the length of the assembly,—and in sizes for ¾" to 2½" pipe and for 1" to 2¾" tube.



Andy Anchor says:
"Don't delay writing for complete details and specifications.

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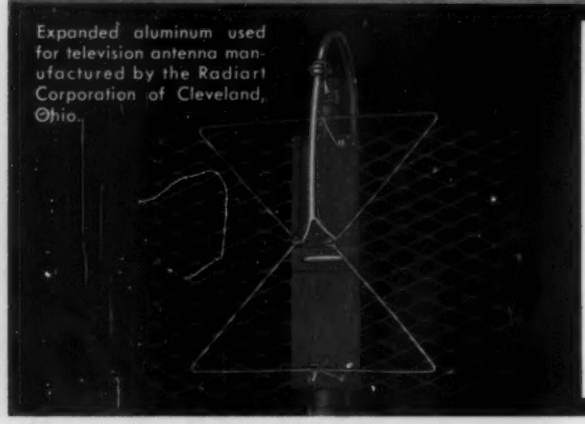
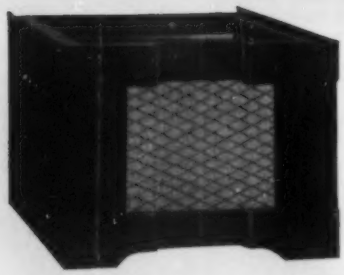
CIRCLE 21 ON READER SERVICE CARD

"Decor-Tenna" by Midwest Naturelite Company, Chicago, Illinois, combines the beauty and utility of Penmetal expanded metal.



Expanded aluminum used for television antenna manufactured by the Radiart Corporation of Cleveland, Ohio.



Television base made by Griffith Co., Parkersburg, W. Va.

Designed with EXPANDED METAL *in mind*

Many products like those above have proved successful because their designers exploited the unique properties of Penmetal expanded metal.

Where else could you find meshes so ideally suited to television applications. Extremely high strength-to-weight ratio permits use of light sections to span large areas economically. Because of great flexibility, only your imagination limits the form it can take. Used decoratively, in a place like a grille, the clean diamond pattern is distinctively appealing—has quality written all over it.

Whether your requirements for a mesh are strength with light weight, workability, beauty, or all three, Penmetal expanded metal can provide the answer. Send for *new* 36-page catalog 521-EM, which gives full details of this versatile material.

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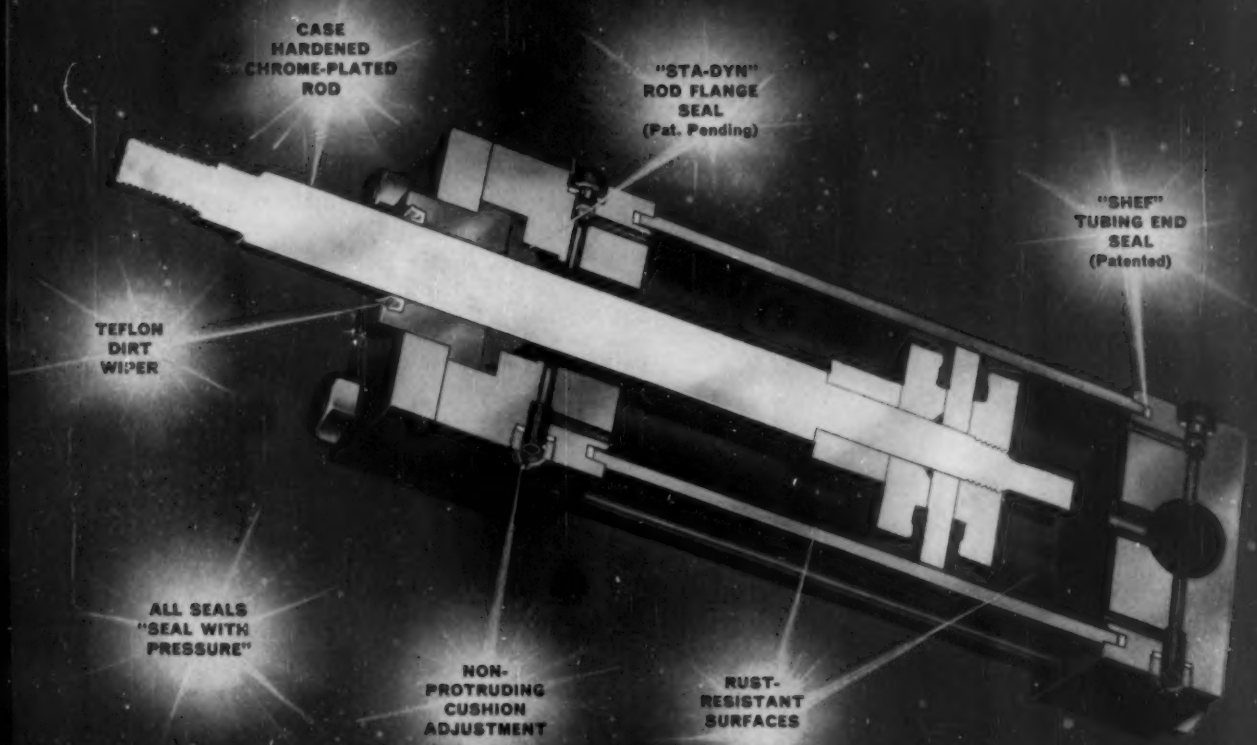
PM-234

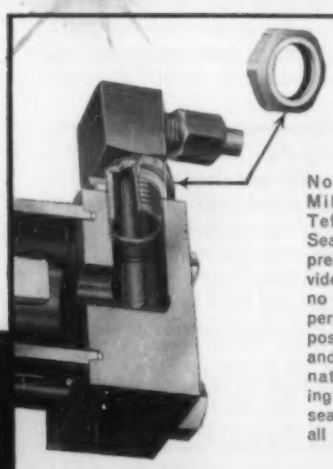
CIRCLE 23 ON READER SERVICE CARD→

Stellar RELIABILITY and ECONOMY


CASE HARDENED CHROME-PLATED ROD
"STA-DYN" ROD FLANGE SEAL (Pat. Pending)
"SHEF" TUBING END SEAL (Patented)
TEFLON DIRT WIPER
ALL SEALS "SEAL WITH PRESSURE"
NON-PROTRUDING CUSHION ADJUSTMENT
RUST-RESISTANT SURFACES

Miller AIR CYLINDERS

PORT SEALS



Now—with every Miller Cylinder—Teflon-sealed Port Seals that "Seal with pressure" are provided as standard at no extra cost. They permit much faster positioning of lines and fittings, eliminate "overtightening" damage, and seal perfectly against all operating media.

Here are eight more reasons why Miller Air Cylinders continue to be the most economical and reliable cylinders that money can buy. These stellar features—including the new port seals—are standard Miller construction—yours at no extra cost. Thus, they provide appreciable savings in original investment—*particularly for those who insist on "J. I. C." quality throughout.* Savings in operating costs are even greater, because these features are proven assurance of longer cylinder life, greater efficiency, reduced maintenance and downtime.

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POINTS OF VIEW

THE QUESTION: *Can thinking*

Last June our editor pooh-poohed Dr Wiener's statement that a robot brain might destroy its creators. Late last month Dr Wiener expanded on his original statement at a symposium of the American Association for the Advancement of Science in Chicago. Here is a condensation of his talk.

Dr Norber Wiener
Institute Professor,
Massachusetts Institute of Technology

The man in the street has an attitude toward cybernetics and automatization which, in my opinion, should be rejected in its entirety. He assumes that machines cannot possess any degree of originality, that "nothing can come out of the machine which has not been put into it." He insists, "a man-made machine must remain continually subject to man, so that its operation is at any time open to human interference and to a change in policy." On the basis of such an attitude, many people have pooh-poohed the dangers of machine techniques, and they have flatly contradicted the early predictions of Samuel Butler that the machine might take over the control of mankind.

It is true that in the time of Samuel Butler, the available machines were far less perilous. They only involved power, not a certain degree of thinking and communication. However, the machine techniques of the present day have invaded these fields as well, so that the image of the actual machine is far different from that which Butler held, and we cannot transfer to these new devices the assumptions which seemed axiomatic a generation ago.

It is my thesis that machines can and do transcend some of the limitations of their designers, and that in doing so they may be both effective and dangerous. It may well be that, in principle, the elements of behavior of any machine made by man can be understood by man sooner or later. But this does not mean that we shall be able to comprehend them in substantially less time than the time of operation of the machine, nor even within any given number of years or generations.

Two properties of machines now widely recognized are that, over a limited range of operation, machines act far more rapidly than human beings, and they are far more precise than man in performing the details of their operations. This being the case, even when they do not in any way transcend human intelligence, they may and do transcend man in the performance of their tasks.

This means that though machines are theoretically subject to human criticism, such criticism may be ineffective until long after it is relevant. By the time that we are able to stop the car it may already have run head-on into a wall.

Machines that Learn

I shall come back to this point later. For the present, let me discuss the technique of machines for a very specific purpose: that of playing games.

The von Neumann theory of games bears no very close relation to the theory used by game-playing machines. These correspond much more to the methods of play used by expert, but limited, human chess-players against other chess-players. Such players depend on certain strategic evaluations which are, in their essence, not complete. While the von Neumann type of play is valid for games like tic-tac-toe with a complete theory, the very interest of chess and checkers is that they do not possess a complete theory. Neither do war, nor business competition, nor any of the other forms of competitive activity in which we are really interested.

The lowest type of chess-playing machine plays in terms of a certain rigid evaluation of plays. Quantities such as the value of pieces gained or lost, the command of the pieces, their mobility, etc., can be given numerical weights on an empirical basis, and a weighting may be given to each next play conforming to the rules of the game. The play with the greatest weight may be chosen. Under these circumstances, the play of the machine will seem to its antagonist —who cannot but evaluate the chess personality of the machine—a rigid one.

The next step is for the machine to take into consideration, not merely the moves as they have occurred in the individual game, but the record of games previously played.

On this basis, the machine may stop from time to time, not to play, but to consider what (linear or nonlinear) weighting of the considerations which it has been given to consider would correspond best to won games as opposed to lost (or drawn) games. On this basis, it continues to play with a new weighting. Such a machine would seem to its human opponent to have a far less rigid game personality, and the tricks which would defeat it at an earlier stage, may now fail to deceive it.

The present level of these learning machines is that they play a fair amateur game at chess, but that in checkers they can show a marked superiority to the player who programmed them after from 10 to 20 playing hours of working and indoctrination. They thus most definitely escape from the complete effective control of the man who made them. Rigid as the repertory of considerations may be which they are in a position to take into consideration, they do unquestionably—and so say those who have played with them—show originality, not merely in their tactics, which may be quite unforeseen—but even in the detailed weighting of their strategy.

The Machine Is no Slave

The problem, and it is a moral problem, with which we are faced is very close to one of the great problems of slavery. Let us grant that slavery is bad because it is cruel. It is, however, self-contradictory as well. We wish a slave to be intelligent, to be able to assist us in carrying out our tasks. However, we also wish him to be subservient. Complete subservience and complete intelligence do not go together. How often in ancient times the clever Greek slave of a less intelligent Roman slaveholder must have dominated the actions of his master rather than obeyed his wishes! Similarly, if the machines become more and more efficient and operate at a higher and higher psychological level, the catastrophe foreseen by Butler of the domination of the machine comes nearer and nearer.

The human brain is a far more efficient control apparatus than is the intelligent machine when we come to the higher logical types. It is a self-organizing system which depends on its capacity to modify itself into a new machine rather than on an ironclad accuracy and speed. We have already made very successful machines of the lowest logical type with a rigid policy. We are beginning to make machines of the second logical type where the policy itself improves on learning. There is no specific limit to the type on which we can construct operative machines, nor is it safe to pronounce exactly on what type the brain is superior to the machine. Yet for a long time at least there will be some type sufficiently high that on this level the brain is better than the constructed machine even though this level may shift upwards and upwards.

The result of a self-programming technique of automatization is to remove from the mind of the designer and operator an effective understanding of many of the stages by which the machine comes to its conclusions and of what the real tactical intentions of many of its operations may be. This is highly relevant to the problem of our being able to foresee undesired consequences outside of the frame of the strategy of the game, while the machine is still in action and before an intervention on our part may avoid these consequences.

Human action is a feedback action. When a machine control operates on its incoming data faster than we can keep up, our supposed ability to control it may be postponed so much that by the time we have understood its dangers, our power to turn the machine off may be long past.

Disastrous results are to be expected when two agencies essentially foreign to one another are coupled in the achievement of a common purpose. If, to achieve our purposes, we use a mechanical agency with whose operation we cannot efficiently interfere after we have started its action (for example, if its action is so fast and irrevocable that we have not the data to intervene before the action is complete) then we had better be quite sure that the purpose put into the machine is the purpose which we really desire and not merely a colorable imitation of it.

Although some readers think Dr Wiener looks like a 19th century European professor, he is actually a dyed-in-the-wool New Englander. A graduate of Tufts and Harvard, he has been associated with MIT for the past 41 years, although he spent a year as visiting professor at Tsing Hua University in Peiping. Called "one of the top six in US mathematics" by *Fortune*, he did research for the Government on the construction of predictors and in the field of guided missiles.

In 1949, he published a book, *Cybernetics*, which attempted to marry the field of mechanisms and the human brain. "I made up the word 'cybernetics' from the Greek for steersman," Wiener has explained. "As the book says, it refers to control and communication in the animal and the machine. The typical example is the governor of a steam engine, which senses mechanically when the engine is going too fast and reduces the supply of steam."

What does Dr Wiener do for relaxation? He writes detective stories under his pseudonym—W. Norbert.

NEW! DUAL TORQUE-LOCKING AND POSITIONING DEVICE

REV-LOK eliminates feedback torque, provides two-directional positioning, drive, over-running and backstopping

NOW! You can have positive and instantaneous stopping of feedback (reverse) torque—it will never reach the driving equipment. For, the complement of sprags in this new Formsprag device is divided into two opposing sets that: instantly stops feedback from either direction, assures equalized radial loading, evenly distributes wear for longer life, and provides multi-contact surfaces for greater holding strength when high feedback torque occurs.

When the device is mounted with the outer race in a fixed position, feedback is stopped by wedging of sprags between output member and I.D. of fixed outer race—feedback never reaches the input shaft. Yet, this new design permits free rotation and transmission of high driving torque in either direction from input to output shaft.

When used as a two-directional over-running clutch, output shaft member is mechanically secured against rotation and outer race then becomes the output member. A slight right or left rotation of input shaft disengages either set of sprags and determines direction of drive, over-running and backstopping.

This versatile device can also be used for two-speed drive and reversing applications. By connecting a low-speed reversible motor to outer race and a high-speed motor to input shaft member, driving torque can be transmitted at two speeds or reversed.

Here is a multi-purpose device, that not only drives, positions, over-runs and backstops in two directions, but also provides automatic, instantaneous and positive prevention of feedback from driven equipment to power source. It is compact, has greater torque capacity for its size and weight and permits higher over-running speeds than any similar device. Operation and features are explained in detail in a new Formsprag technical paper, send for your free copy.

FORMSPRAG COMPANY, 23607 Hoover Road, Dept. 105, Warren (Detroit), Michigan
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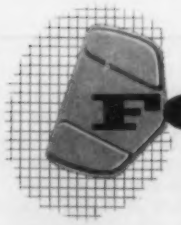
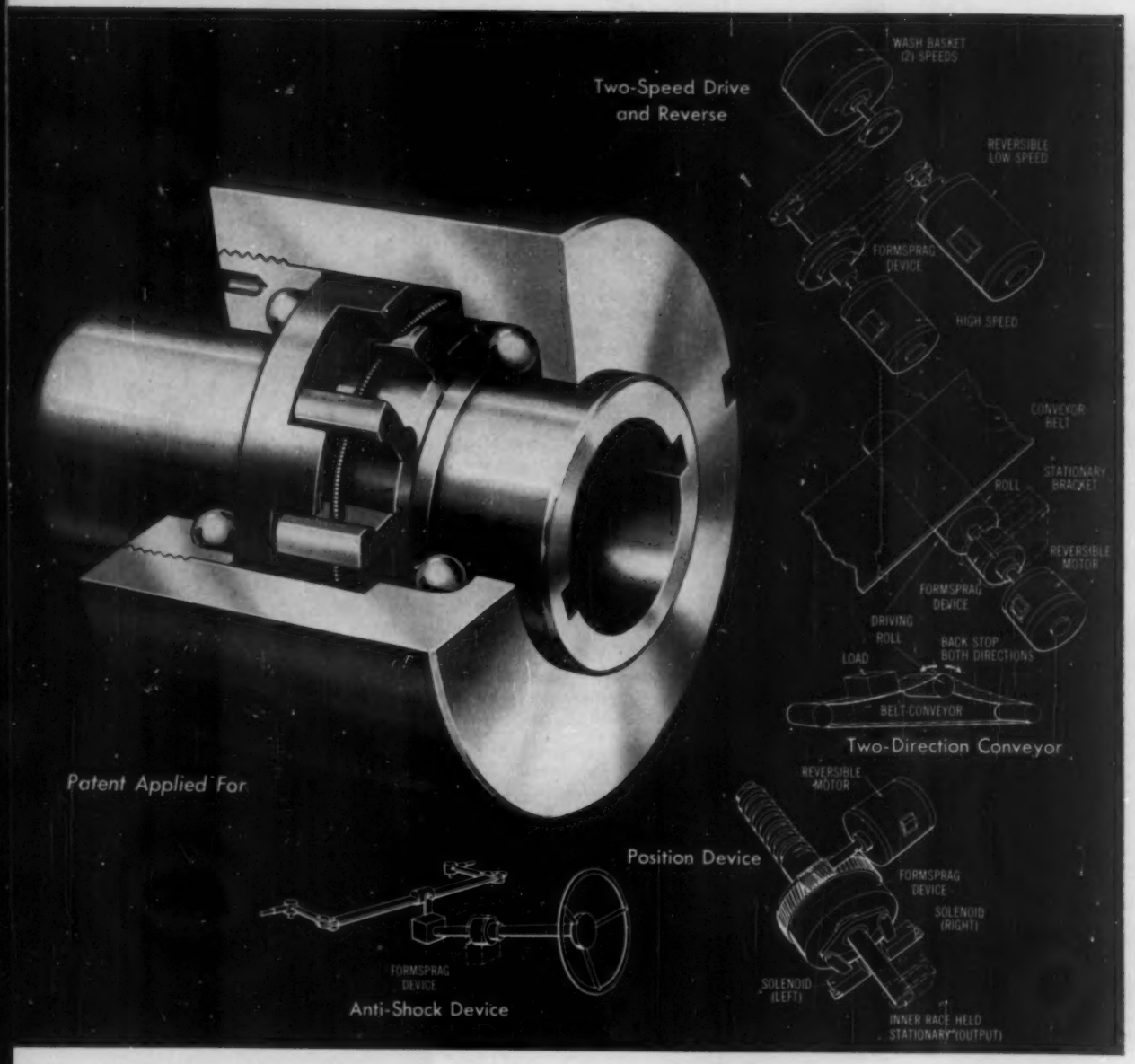
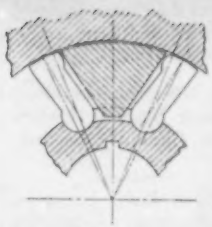


FORMSPRAG CLUTCHES

Precision Power Transmission Products



BECAUSE there is a complement of sprags arranged in opposing pairs, there is always a multiple number of contact surfaces engaging the outer race when feedback or backstopping conditions are present. This provides equalized radial loading and strong holding torque against even unusually heavy feedback.



The entire complement of sprags, which is a part of the output member assembly, rotates at driving speed while outer race remains stationary. Thus, sprags are in light contact with the outer race and are always in position to pick up the feedback load at constantly changing points on the outer race. This design feature assures longer life through even distribution of wear over entire surface of outer race. With sprags in constant contact with outer race, any independent movement of output shaft causes instantaneous locking of sprags—there is no backlash on output shaft.

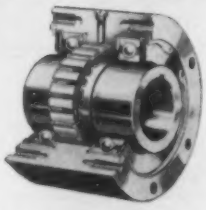
RAWSON Centrifugal Clutches

No-Load Motor Starts, Cushioned Starting of High-Inertia Loads, Overload Protection.

OTHER FORMSPRAG PRODUCTS

FORMSPRAG Over-Running Clutches

For Every Over-Running, Indexing & Backstopping Application



READER / TO EDITOR

What's Honorable

To the Editor:

Your editorial, "Cold-War Creep and Fatigue" (Dec 7, p 61), was timely and true. We have been so imbued with the virtues of nonaggression that we allow it to interfere with our self-defense. Posthumous praises and medals are issued for those who have sacrificed their lives that others may live free from tyranny. Yet as a nation we hesitate to offer a sacrifice because we have been taught to try everything else. We often quote "all's fair in love and war," but we honestly don't believe it. Our plague is still that inner conflict between what we have been taught is honorable and what we know our opponents are doing.—JESSE W BORN
Westlake, Ohio

Science and Society

To the Editor:

In the November 9th issue, B A Leerburger, Jr. discusses the popular resistance to new ideas and cites religious resistance to inquisitive investigation. (Interesting to Note, p 5)

It's too bad that old Pope Paul V and his Church are always depicted as barriers to science and scientific investigation as in the Galileo case. The Catholic Church does not deny the facts in this case merely because it would be better if they were not true. Admittedly the Church's action really gummed up the works for Galileo and seemingly for his Copernican theory.

However, Galileo violated his own principles as a scientist when he advanced a mere hypothesis (supported only by analogy) as conclusive fact and then indulged in a little theological speculation on the side. Had he advanced his theory as a theory and theory only and had he not jumped specialties, he would have been acting scientifically and the Church would have had no grounds for criticism.

Is it any different today? Can a geologist validly use a mere theory to prove a new principle of psychology (even if the theory would prove true later)? I hold that Galileo should be duly recognized for his scientific contributions, but also hold that it is incorrect to say that religion has acted as a barrier to the orderly inquiring mind. —JAMES F MACHEN
Assistant Professor, Univ. of Toledo

To the Editor:

Enjoyed your article on Science vs Society in which you mention Galileo and Da Vinci. These two seem to have been so far ahead of their contemporaries in many fields of thinking that they are fantastic. —P G GLEASON
Desco Products Van Nuys, Calif.

To the Editor:

Now that you have described the struggle of science against the social forces, such as the Church and political groups, please be open-minded and fair enough to describe its struggle against itself. Despite the established patterns of divine messages given to the world down through the centuries, science (not all scientists) refuse to pay heed to the warning that unless we obey God's laws first, we will destroy ourselves with our own tools.

Open-mindedness is to creativity what food is to the body. Yet these so-called scientists refuse to open their minds to the thousands of reports on Lourdes, the writings of the Apostles and other sources that can be proved true by scientific analysis. —WALTER A MURPHY
Hyde Park, Mass.

• Whenever the fear of social ostracism, religious penalties or political interference (McCarthyism) is held over any man of science, the quest for truth and knowledge is hampered.—BAL

COMING EVENTS

JANUARY

18-21 . . . . American Astronautical Society, 6th Annual Meeting, Statler-Hilton Hotel, New York.

25-28 . . . . Plant Maintenance & Engineering Show, Convention Hall, Philadelphia.

25-28 . . . . Institute of the Aeronautical Sciences, 28th Annual Meeting, Hotel Astor, New York.

26-27 . . . . Society of Vacuum Coaters, 3rd Annual Meeting, Hotel Biltmore, New York.

31-Feb 5 . . . . American Institute of Electrical Engineers, Winter General Meeting, Hotel Statler, New York.

FEBRUARY

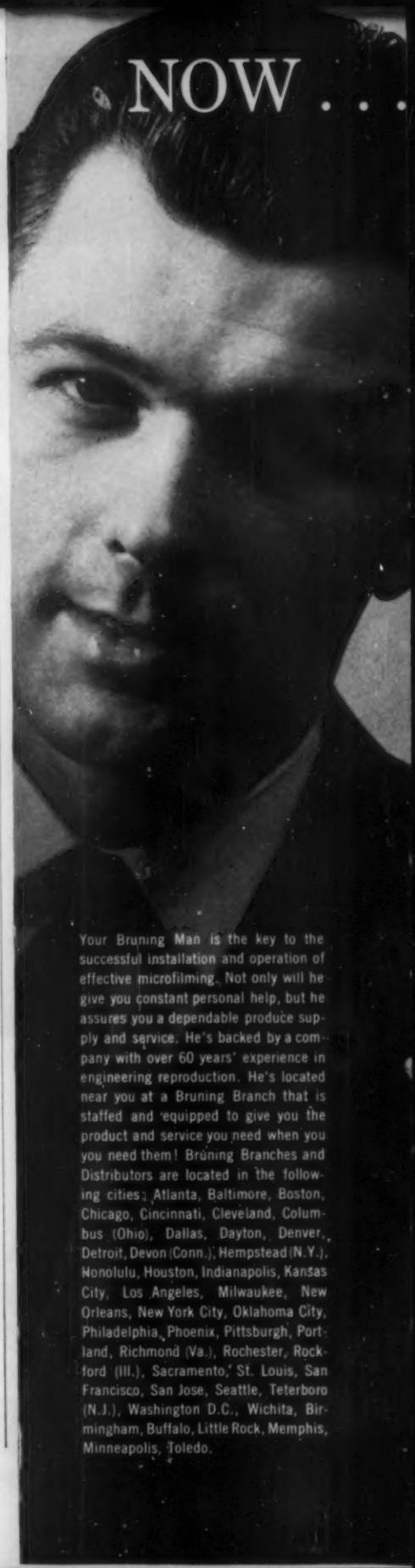
2-4 . . . . Society of the Plastics Industry, 15th Annual Technical and Management Conf., Edgewater Beach Hotel, Chicago.

3-4 . . . . Armour Research Foundation, 6th Annual Midwest Welding Conference, Illinois Tech Chemistry Building, Chicago.

3-5 . . . . Institute of Radio Engineers, 1960 Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles.

10-12 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, Univ of Pennsylvania, Solid-State Circuits Conference, Philadelphia.

24-25 . . . . Malleable Founders Society, Technical and Operating Conference, Cleveland, Ohio.



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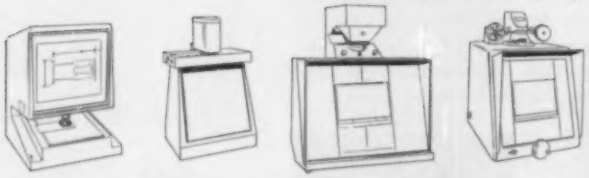
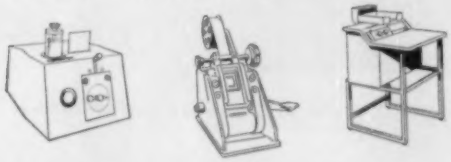
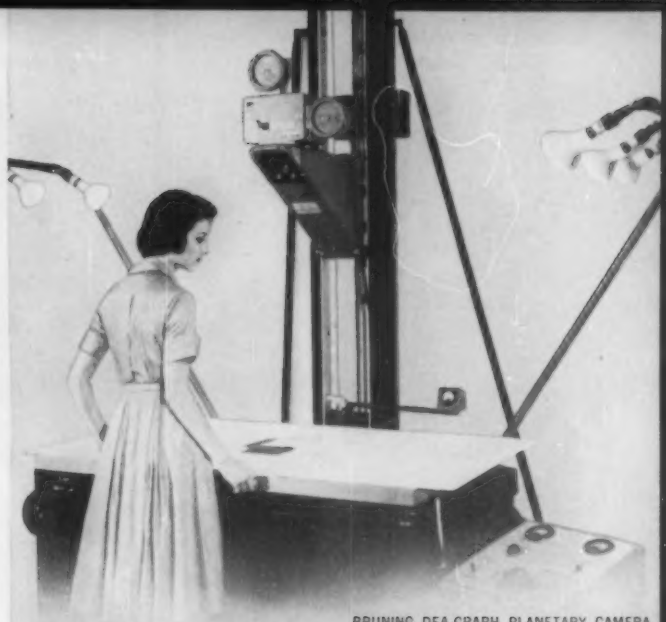


Bruning's complete line of microfilming equipment includes Dea-Graph Cameras, Filmsort Mounters and Readers, Filmsort Aperture Cards, and Bruning Reader-Printers





BRUNING DEA-GRAPH PLANETARY CAMERA
The first top-quality, moderately priced 35 mm. camera. Converts easily into an enlarger unit. Guaranteed resolution of 120 lines per millimeter @ 30X reduction.

BRUNING FILMSORT CARDS AND MOUNTERS
Bruning offers a complete Filmsort service for mounting microfilm on file cards and for duplicating these cards. Hand mounters, semi-automatic and automatic mounters are available.

BRUNING FILMSORT DESIGNER 184 READER
Outstanding features include an exclusive 65 mm. f/4 lens that transmits 2½ times more light than conventional f/6.3 lens. Bruning offers a variety of readers and inspectors in a wide range of prices and sizes.

motors for commercial applications

HIGHEST TORQUE FOR SMALLEST SPACES

Missile designers are well acquainted with the extremely high torque available from a planetary geared precision miniature Globe motor. Units similar to the one pictured can produce up to 150 inch pounds of torque!

And more and more designers are finding that these motors offer outstanding advantages for commercial applications as well. Universal, a.c., or d.c. types are available from 7/8" to 2 1/4" in diameter. They can replace larger, ordinary motors at competitive cost, and deliver important bonuses too. They perform reliably under conditions that would soon ruin ordinary motors—high humidity and temperature, jarring shock and vibration, dust and fume-laden atmospheres.

Globe speed reduced motors are engineered to fit your specific application as no "off the shelf" motor can. Standard component design is the secret; for example, 83 even ratio planetary reducers are available to give the speed and torque you need. Many parts are inventoried. Design and production efficiency will save you money. If you have a commercial application that demands a smaller, more powerful, more reliable and competitively priced motor, then consult Globe first. Write for Bulletin ACG. **Globe Industries, Inc.,** 1784 Stanley Avenue, Dayton 4, Ohio.

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PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS. TIMERS. GYROS. STEPPERS. BLOWERS. MOTORIZED DEVICES

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product saving protection

eye appeal that adds sales appeal

quickly applied... and removed

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save time, trouble and $$$

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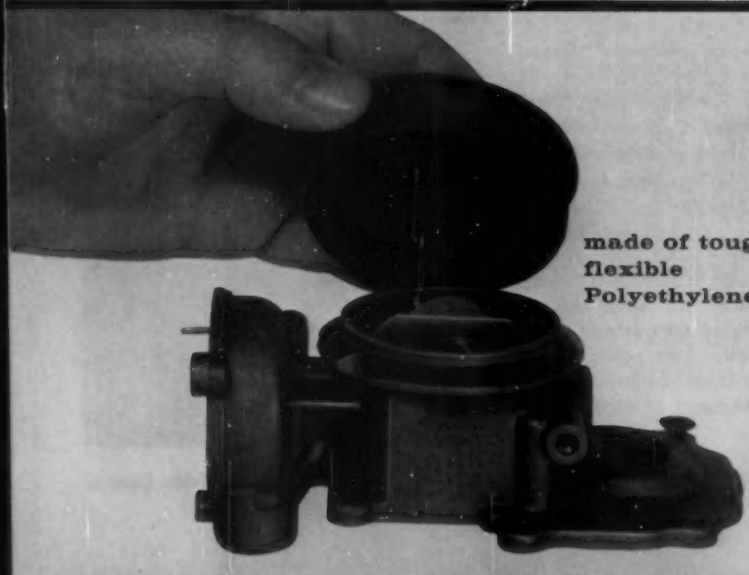

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PLUGS

If your product has moving parts operating in a fluid, you can reduce costly wear with Lisle Magnetic Plugs.

Ferrous metal particles in a lubricant are a major cause of wear. The Lisle Magnetic Plug removes these particles from the lubricant — assures longer, quieter operation of the products you make.

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Clarinda, Iowa

FOR YOUR INFORMATION (personal)

Shows you the way to go home

A "batteryless" flashlight, only ¾ in. dia and weighing less than an ounce with its chain, has been developed in Germany. Actually, it does have a power source—but a rechargeable one. It will operate for a month, the manufacturer says; then "just leave the ball in the recharger case over night, and it's ready to go again." The recharger case is 3 by 1¼ by 1 in.; accommodates two 1.5-v hearing-aid A batteries. It's available in the US from Hollis Co, 1133 Broadway, NY 10, for $6.95.

Barometer rising. Outlook—rain
Barometer falling. Outlook—fair

All fouled up? Not at all. These are just a few of the exceptions that prove the barometer rules. As the Weather Bureau points out, pressure alone is not a foolproof guide to weather prediction. It's the level of pressure, the direction of change, and the direction of the wind that are important.

For example, with the wind SW to NW and the barometer at 30.10 to 30.20 and steady, the indication is fair, with slight temperature change. But if the barometer is rising rapidly, the outlook is rain—within a day or two.

If the wind is E to NE and the barometer is falling slowly from 30.10 or above, rain is on the way. In this case, though, it may not arrive for several days. Under the same barometric conditions, if the wind is S to SE, it means rain within 24 hr.

Says the Weather Bureau: The best way to be a good weather forecaster is to study the instructions that come with your barometer—and then check its reading with the weather reports on your local radio station.

Stick-on paint

You can paint without brush or roller; and without smell, drip or streak, with a new pre-dried, self-adhesive paint, says Morgan Adhesives Co. According to Morgan, it's "pure paint" that comes sealed in a sandwich between two layers of paper—strip off the bottom, stick the paint down, and then remove the protective cover, as shown in the photograph. The paint is now being made in fluorescent colors, can be used for signal markers and warning signs as well as for decoration. Free samples are available from Morgan (a Bemis Bro subsidiary) at Stow, Ohio.

—ARG

PARKER-HANNIFIN FLUID SYSTEM COMPONENTS

Hannifin high-pressure hydraulic cylinders feature a drip-free rod gland with "LIPSEAL"® and "WIPERSEAL." This feature, plus straight-thread, O-ring-sealed ports, insures leak-proof cylinder installations.

from **PARKER-HANNIFIN...**

straight-thread ports and fittings

for leak-proof

hydraulic systems

Parker straight-thread hydraulic fittings, mated with S.A.E. bosses (offered at *no extra charge* on Hannifin cylinders), guarantee leak-proof cylinder port connections.* This use-proved sealing method is J.I.C. recommended.

To insure leak-proof performance throughout your hydraulic systems, Parker offers both "Triple-lok" flare-type and "Ferulok" flareless fittings for leak-proof tube connections. Where you need high pressure, permanent-end hydraulic hose assemblies, Parker supplies "Krimp-lok." And for fast, leak-proof field service or replacement, Parker "Hoze-lok" fittings require no skiving of the hose, need a minimum of tools for assembly.

Your Parker-Hannifin man is qualified to help you with installation problems. He'll also help you plan your hydraulic layouts.

**Both Parker fittings and Hannifin cylinders are still available with "dry-seal" pipe threads.*

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

HANNIFIN COMPANY
545 S. Wolf Road, Des Plaines, Illinois

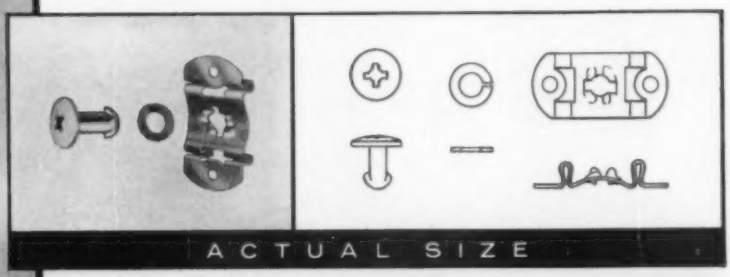
DIVISIONS OF PARKER-HANNIFIN CORPORATION

Now...

miniature

¼ turn

fasteners!



LION *miniature* FASTENERS

¼ TURN OPEN • ¼ TURN CLOSED

LIGHTWEIGHT • STRONG
MINIMUM ENVELOPE

A new size has been added to the Lion family of quick-opening fasteners . . . a miniature size. Small, compact, yet strong and rugged, these miniatures aid in reducing overall dimensions and weight without sacrificing the important advantages of larger Lion Fasteners.

ALIGNMENT NOT CRITICAL

Stud "floats" to accommodate misalignment. The hole in the sheet for the stud has an area 60% greater than the stud diameter. This allows a .030 float in all directions.

WIDE VARIATION IN STACK HEIGHT

Six different studs accommodate total material thicknesses (both sheets) of .040 minimum to .159 maximum.

Total sheet thickness served by any one stud may vary as much as .019 without affecting operation. A Lion Miniature Stud, specified for a thickness of .0863, for example, will accommodate total sheet thicknesses from .080 to .099.

SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the exclusive Lion swaged nose design. All the metal is put to work. There are no holes, thin cross pins, or milled slots to weaken the cross-section. Case hardening assures long, trouble-free service without wear.

LARGER SIZES AVAILABLE

Lion Fasteners are also available in two larger sizes—No. 5 (mil spec) and No. 2—to meet the needs of aircraft, missile and ground support equipment. The heads are supplied in a wide variety of styles including oval, flush, wing, ring, notched and knurled.

FREE!

FASTENER HANDBOOK

Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and many other special fasteners.

Write to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pennsylvania.

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LION *Aviation* FASTENERS

one of the

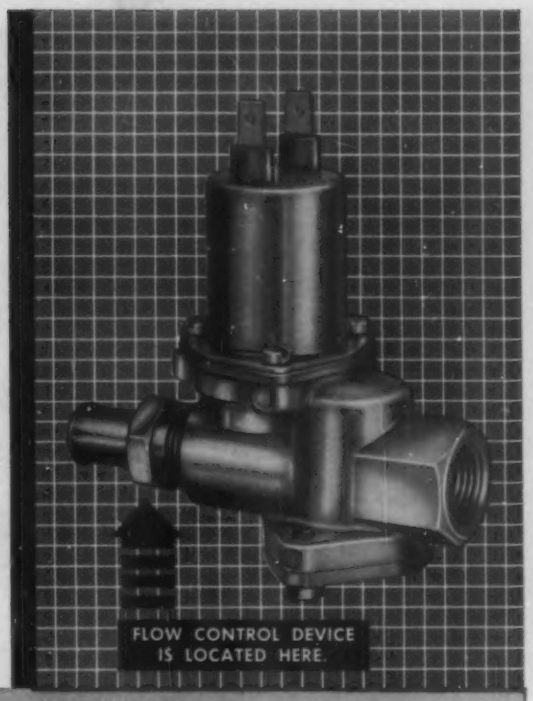
SOUTHCO LION **FASTENERS**

If you are controlling

Water Flow

—specify the Detroit S-25 solenoid valve. It gives positive opening and closing from ¼ to 6 gpm—2½ to 200 psi—up to 180°F*. The valve has an optional flow control device built into the outlet to insure accurate water delivery. It's available with pipe, tubing or hose connections and with a wide variety of terminals. Many different mounting brackets can be obtained. Listed by Underwriters' Laboratories.

*Up to 200° for special applications



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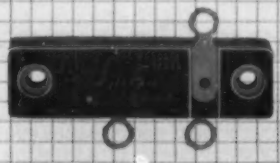
DETROIT CONTROLS DIVISION

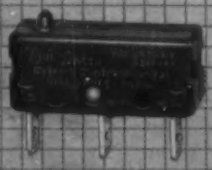
CLASS 1



SHOWN ACTUAL SIZE

LENGTH 1-5/8"—WIDTH 7/16"—DEPTH 11/32"

CLASS 4



SHOWN ACTUAL SIZE

LENGTH 1-3/16"—WIDTH 7/16"—DEPTH 17/32"

If you are controlling

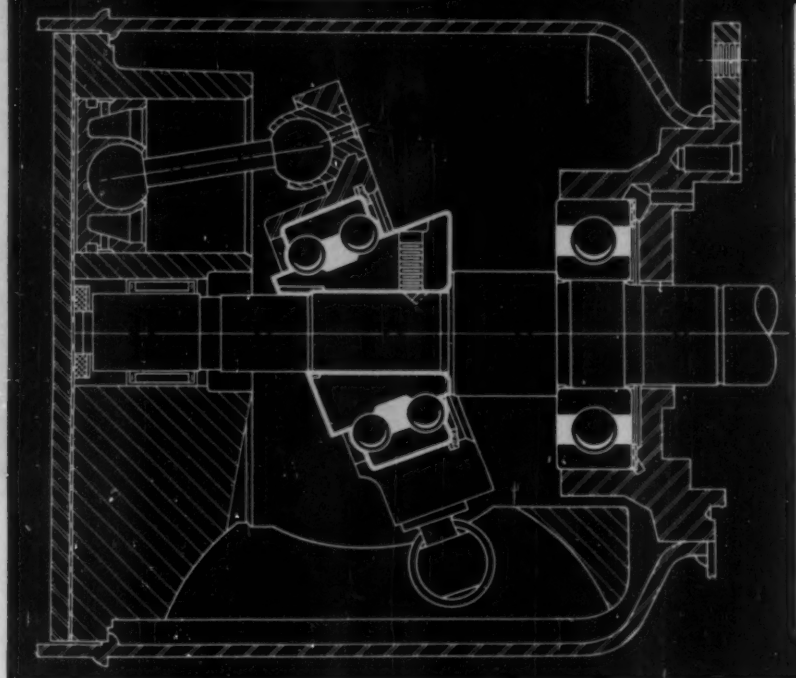
Electric Current Flow

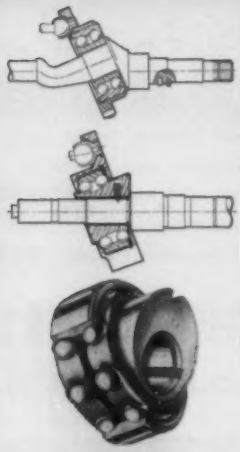
—and want positive action in a small space, look to a Detroit TyniSwitch®. These miniature snap switches give you the long life and precision you need, are virtually bounceless and resist shock and vibration. Class 1 TyniSwitches are top mounted and top actuated and Class 4 all side mounted and top actuated. Both have a wide variety of actuators and terminals. Listed by Underwriters' Laboratories.

There are many applications where these Detroit products can be used as a team—others where they are used alone. Write for Bulletin 275 covering the S-25 solenoid valve and Bulletins 263 and 270 on TyniSwitches. Detroit Controls Division of American Standard, 5900 Trumbull Avenue, Detroit 8, Michigan.

Underwriters' Laboratories listed and Canadian Standards Assoc. approved.
15 Amp. 125/250 V. A.C. Non-Ind. 1/2 H.P. 125/250 V. A.C.
Contractual approvals for U.S. Gov't applications

CASE HISTORIES





Redesign of high capacity compressor shaft and bearing assembly eliminated costly angled shaft in favor of unique, efficient ball bearings.

Illustration: Courtesy, Frigidaire Division, General Motors Corporation

Unique N/D Wobble Plate Ball Bearing Simplifies Axial Compressor Design!

CUSTOMER PROBLEM:

In developing the ideal compressor for automobile air conditioning unit, customer engineers faced the problem of further design simplification and refinement of pilot model.

SOLUTION:

N/D Sales Engineer, in co-operation with customer, pointed out a possible design simplification in the crankshaft bearing assembly. By providing a specially designed N/D precision ball bearing with shaft bore at an angle, a straight shaft could replace the original pilot model crankshaft. The wobble plate angle would then be supplied by the bearing rather than the shaft. First tests proved the new and simpler shaft/bearing assembly met customer's rigid performance standards in high capacity compressor. Final testing of some 300 pilot models, both in the laboratory and on road test cars, finalized the design. Now . . . . all GM air conditioner equipped cars are cooled with the aid of N/D ball bearings.

If *you're* working on new designs . . . or redesigning, why not call your N/D Sales Engineer. He knows the performance possibilities of virtually every ball bearing made . . . and, *he knows what can be done with special bearing designs!* For more information write New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE

BALL BEARINGS

proved reliability you can build around

PRODUCT ENGINEERING HORIZONS

January 18, 1960

HE DID IT!

Newspapers, a few weeks back, were filled with stories of TV fixes and drug overpricing, while the news magazines carried obituaries for the Edsel. All these stories were alike in a peculiar respect; they talked of who or what was to *blame* for the problem. One series of reader letters included this word "blame" at least a half-dozen times.

This suggests that we ask ourselves a basic question: *Are we trying to fix the trouble, or just to fix the blame?*

One is constructive, the other destructive. We can remember teachers, bosses and executives through the years who always had the latter approach to a problem. Pin the blame on somebody—anybody—and perhaps the problem will disappear. We've seen committees do it, service departments do it, suppliers do it—and even governments.

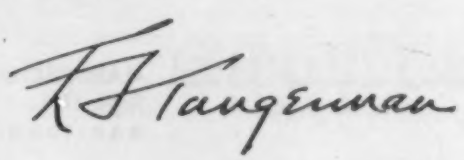
None seemed to realize that selecting a culprit is never the end; it often indicates a greater culprit who escapes by passing the buck, letting some one else take the rap.

The Supreme Court made a historic decision in this regard several years ago; they gave as their opinion that culpability might extend to the maker of a product as well as the user or operator. Interpreted literally, such an opinion is ridiculous; the auto maker should not be liable for the drunken driver nor the drug maker for the mad doctor.

But the auto maker should be responsible for the brakes that fail from faulty design, the steering gear that comes apart for the same reason. The drug maker should certainly accept responsibility for the faulty batch of drugs or the defective container.

A definition of the professional man, quoted recently by ASME President Warren: "One with a special body of knowledge and understanding toward which he feels three compulsions: to use it in the public interest, to add to it by his own efforts, and to teach this knowledge and this understanding to his contemporaries and to the coming generation." Unless we stretch the first compulsion to include it, this definition skips the basic characteristic of the professional man: *He is responsible for the results of the use of his knowledge.*

It seems to us, therefore, that the design engineer has the fundamental responsibility to check his designs for trouble and to design and re-design until the bugs are out of it. The product should have safety and service built in; it should have the morality and integrity that the subjects of the recent investigations seemingly didn't. The search should be for trouble and how to correct it, not for a scapegoat upon whom to pin the blame.



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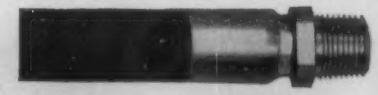
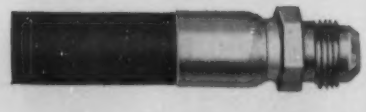
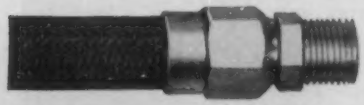


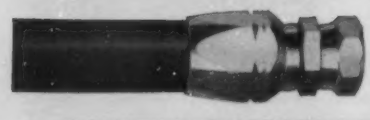
Permanently Attached Male (NPTF) for 1, 2 and 3 Wire Braid rubber cover hose. Plated to prevent rust and corrosion.
Sizes: ¼" thru 2".
Wkg. Press.: 375—5000 p.s.i.



Permanently Attached Male Flare (JIC) for 4 and 6 Spiral Wire Braid rubber cover hose. Used for Ultra High Pressure.
Sizes: ½" thru 1½".
Wkg. Press.: up to 7500 p.s.i.

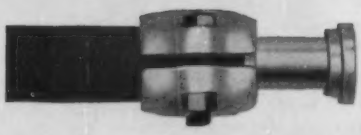


Reusable Male (NPTF) for cotton and rubber cover hose. No skiving necessary.
Sizes: ¼" thru 2".
Wkg. Press.: 350—3000 p.s.i.



Reusable Swivel Female for 1 and 2 Wire Braid rubber cover hose. Easy field replacement.
Sizes: ¼" thru 1¼".
Wkg. Press.: 375—5000 p.s.i.

Permanently Attached Flange Head Couplings for 1 and 2 Wire Braid rubber cover hose. Available in angles to 90°.
Sizes: ½" thru 2".
Wkg. Press.: 375—5000 p.s.i.



Clamp Type Couplings with split flange stems for 1 and 2 Wire Braid rubber cover hose. Exclusive "Inter-Lock" feature.
Sizes: ½" thru 2".
Wkg. Press.: 375—5000 p.s.i.

Permanently Attached Power Steering Assemblies to meet all requirements—designed to your specifications.

Permanently Attached Air Conditioning Assemblies for automotive use—designed to your particular specifications.

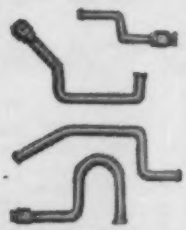
It's a known fact that many leading Original Equipment Manufacturers submit their original specifications for their *first* quotation to Eastman.

EASTMAN's unequalled experience in hydraulic conversion, plus many original designs shown in a few popular Eastman fittings at the left—give your product an appearance of quality that improves its competitive position. These assemblies are available in all thread styles and sizes.

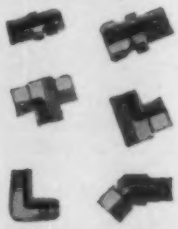
EASTMAN Engineering Service... Backed by Unequalled Experience

It is also a known fact that Eastman's co-operative engineering counsel and service is highly respected and often requested by leading OEM's. Let Eastman engineers help you lay out your fluid power lines—from pump to point of work—effecting economies in design, improving performance and increasing user satisfaction.

Let EASTMAN recommend the *best assembly . . . for the best performance . . . at the lowest cost.*



Bent Tubing with the necessary fittings to meet your own specific requirements.



Adapters, Adapter Unions and Boss "O" Ring Fittings. All types and sizes available.

FOR ADDITIONAL INFORMATION, WRITE EASTMAN MFG. CO., MANITOWOC, WISCONSIN OR PHONE: MURRAY 4-4495

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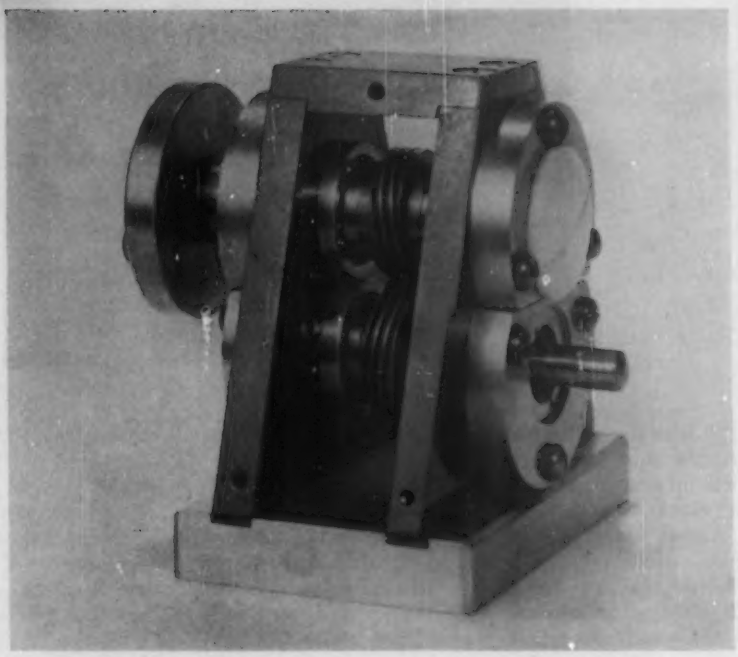
MANITOWOC, WISCONSIN

WRITE for Eastman Technical Bulletins Nos. 100 and 200 on High, Medium and Low Pressure Hydraulic Hose Assemblies.



for self-locking at high efficiency . . .

the TWINWORM GEAR

Developed by an Israeli engineer, this innovation in gearing combines two worm-screws to give self-locking characteristics, or to operate as a fast-acting brake when power is shut off. Model above shows basic components.

NICHOLAS CHIRONIS
Associate editor

The term "self-locking" as applied to gear systems denotes a drive which gives the input gear freedom to rotate the output gear in either direction—but the output gear locks with the input when an outside torque attempts to rotate the output in either direction. This characteristic is often sought by designers who want to be sure that loads on the output side of the system cannot affect position of the gears. Worm gears are one of the few gear systems that can be made self-locking, but at the expense of efficiency—they seldom exceed 40%, when self-locking.

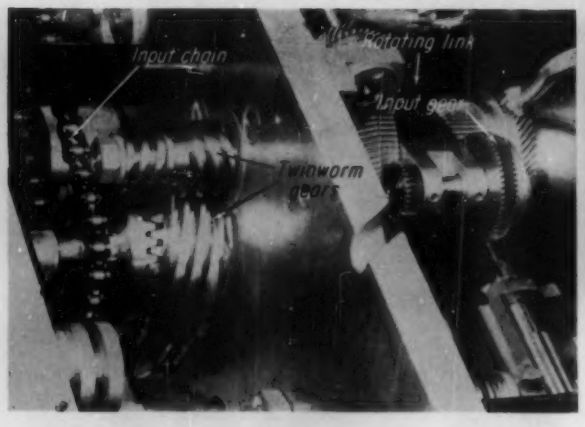
Last month, however, at an ASME meeting in Atlantic City, an Israeli engineer displayed a simple, dual-worm gear system that not only provided self-locking with over 90% efficiency, but exhibited a new phenomenon which the inventor calls "deceleration-locking."

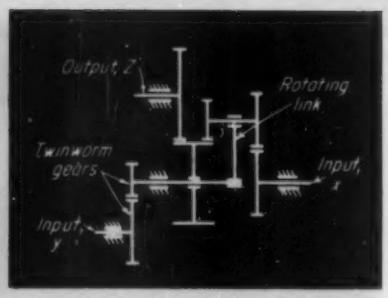
ASME reaction to the new drive varied—some engineers thought it the most revolutionary gear system in modern times; others considered it no more than a manufacturing trick. A point in favor of the inventor—B. Popper, an engineer with the Scientific Department of the Israel Ministry of Defense in Tel Aviv—is that his "Twinworm" drive has been employed in Israel-designed counters and computers for several years and with marked success.

The Twinworm drive is quite simply constructed. Two threaded rods, or "worm" screws, are meshed together. Each worm is wound in a different direction and has a different pitch angle. For proper mesh, the worm axes are not parallel, but slightly skewed. (If both worms had the same pitch angle, a normal, reversible drive would result—similar to helical gears.) But by selecting proper, and different, pitch angles, the drive will exhibit either self-locking, or a combination of self-locking and deceleration-locking characteristics, as desired. Deceleration-locking is a completely new property best described in this way.

When the input gear decelerates (for example, when the power source is shut off, or when an outside force is

HOW TWINWORM WORKS A COMPUTER





INTERACTION BETWEEN INPUTS (photo) is prevented by connecting one input to Twinworm; sketch shows schematic of computer mechanism.

applied to the output gear in a direction which tends to help the output gear) the entire transmission immediately locks up and comes to an abrupt stop moderated only by any elastic "stretch" in the system.

Almost any type of thread will work with the new drive—standard, 60° screw threads, Acme threads, or any arbitrary shallow-profile thread. Hence, the worms can be produced on standard machine-shop equipment such as lathes and automatic screw machines, although a gear-milling machine may be best for the more precise applications. This puts the Twinworm system into the low-cost category.

JOBS FOR THE NEW DRIVE

Applications for Twinworm can be divided into two groups:

(1) Those employing self-locking characteristics to prevent the load from affecting the system.

(2) Those employing deceleration-locking characteristics to brake the system to an abrupt stop if the input decelerates.

Self-locking Applications

Differential gears in computing mechanisms. A differential is basically an adding device in which input rotations x and y are added together to give a proportional output rotation z. Problem here is that if the resisting torque at z is sufficiently great, then input x might rotate shaft y at the expense of rotation at z. For example, what should have been $5 + 0 = 5$, may turn out to be $5 + (-2) = 3$.

This interaction between inputs is prevented by connecting one (or both) of the input shafts to a self-locking Twinworm drive (see illustrations above). Conventional self-locking worm drives (worm shaft plus worm wheel) are too low in efficiency and cannot easily be made to produce one-to-one—and certainly not a stepped-up transmission ratio, as is usually desired in differentials.

Mechanical counters. This is the application that led to development of Twinworm gears. Popper was given the problem of developing a gear system that would permit inputs to be made directly to any one of five digit-wheels. The inputs were to affect higher-digit wheels (see upper left sketch, on following page), but not the lower digits. This was accomplished by coupling Twinworm drives to slip clutches. An impulse to digit-wheel 3 would cause it to also rotate wheel 4, but the Twinworm between wheels 2 and 3 would lock up, causing it to slip against its clutch. Standard worm gears were originally employed but their low efficiency was compounded because of their series-arrangement. If each worm has 40% efficiency, the over-all efficiency, when impulse is to wheel *1*, is $0.4 \times 0.4 \times 0.4 \times 0.4 = 0.0256$ or only 2½%.

Hoists and lifts—Popper believes the drive could be employed advantageously wherever loads must be raised, such as in hoists, elevators, lift trucks, mechanisms for adjusting car windows, and so forth. The drive not only prevents the load from rotating the gears but can be so designed that the same input torque is required both for raising and lowering the load (even without a counterweight). In the illustrations above, for example, one can crank the load to any position with the same force—and remove his hand without fear that the load will fall. Also, the power unit (if a motor is employed) will be the smallest possible.

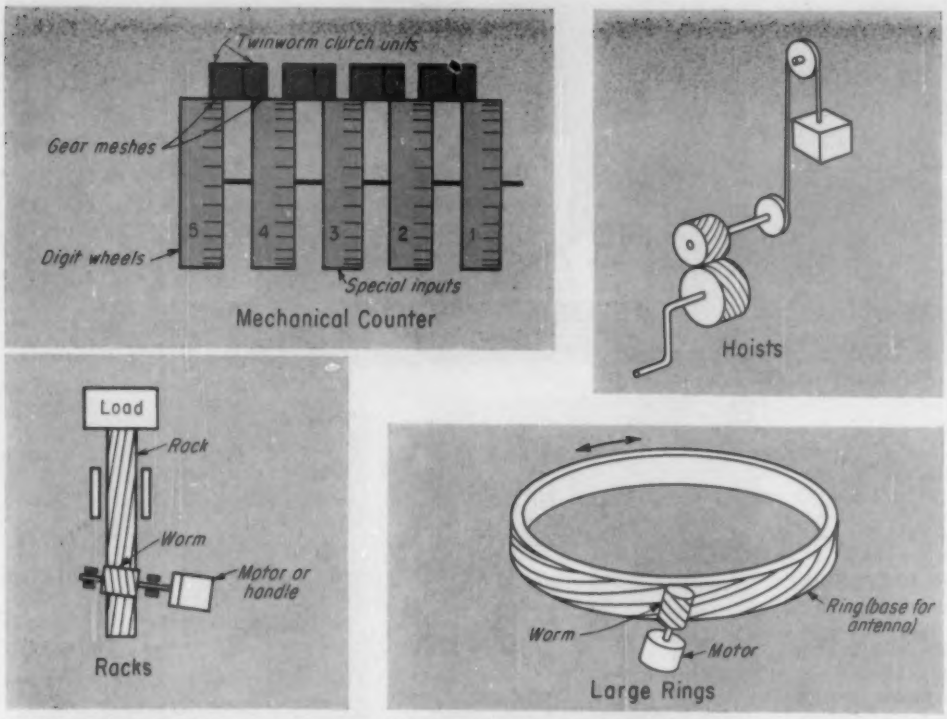
Racks and rings—Where only linear output motion is needed, the Twinworm principle could be made into a worm-and-rack transmission (illustrated above). Same advantages will be found as with hoists—the load cannot rotate the worm, and the same torque is required to raise or lower the load. Possible applications include jacks, automatic mechanisms for closing of doors in buses or trains (no need for a power cylinder to keep the door closed). A jack, when operated by hand, would need only one-quarter the effort needed by common jacks using the screw-and-nut principle. (A screw-nut combination is also self-locking but with an efficiency usually about 20%).

The principle of the drive could also be applied to large external or internal rings; for example, for rotation of antennas. Wind loads on the antenna cannot shift the ring. Also, the principle is applicable to the bevel-gear system.

Deceleration-locking Applications

By connecting a Twinworm drive designed for deceleration-locking to a servo, overshoot of the servo could be

OTHER APPLICATIONS FOR TWINWORM



MECHANICAL COUNTER was first application. Sketches show three other Twinworm possibilities.

completely prevented because, as soon as the servomotor is stopped, the drive will lock up. The drive can thus replace conventional clutch-and-brake servos.

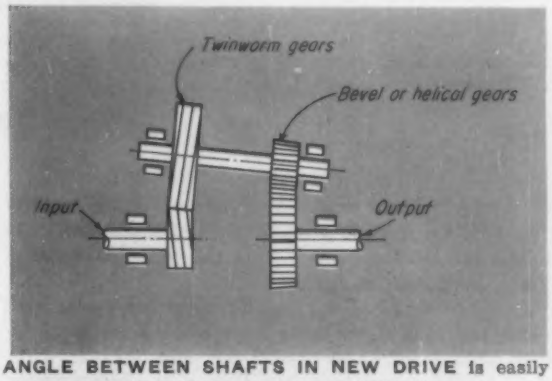
Other possible applications include use in drill presses, contour milling machines, dental drills—wherever it is desirable to bring the tool to an immediate stop as soon as the driving force stops.

Flywheels or other masses attached to the output shaft would accentuate the deceleration-locking effect—when the input gear wants to stop, the inertia of the flywheel will tend to keep the output gear going. Thus, the inertia of the flywheel, instead of adding to the total inertia of the system, reduces its effective value almost to zero during deceleration of the input. On the other hand, locking action can be slowed down by employing frictional devices, such as leaf springs, to rub against the output shaft.

HANDLING MISALIGNMENT

For many applications, the fact that the two worm shafts are slightly skewed will not be a problem. However, where the input and output shafts must be parallel, a universal coupling or flexible drive can connect the worm drive to the rest of the system.

Bevel or helical gears can also be used, especially where the worm drive is to be part of a gear-reduction system (illustrated at right).



ANGLE BETWEEN SHAFTS IN NEW DRIVE is easily compensated by pairing with bevel or helical gears.

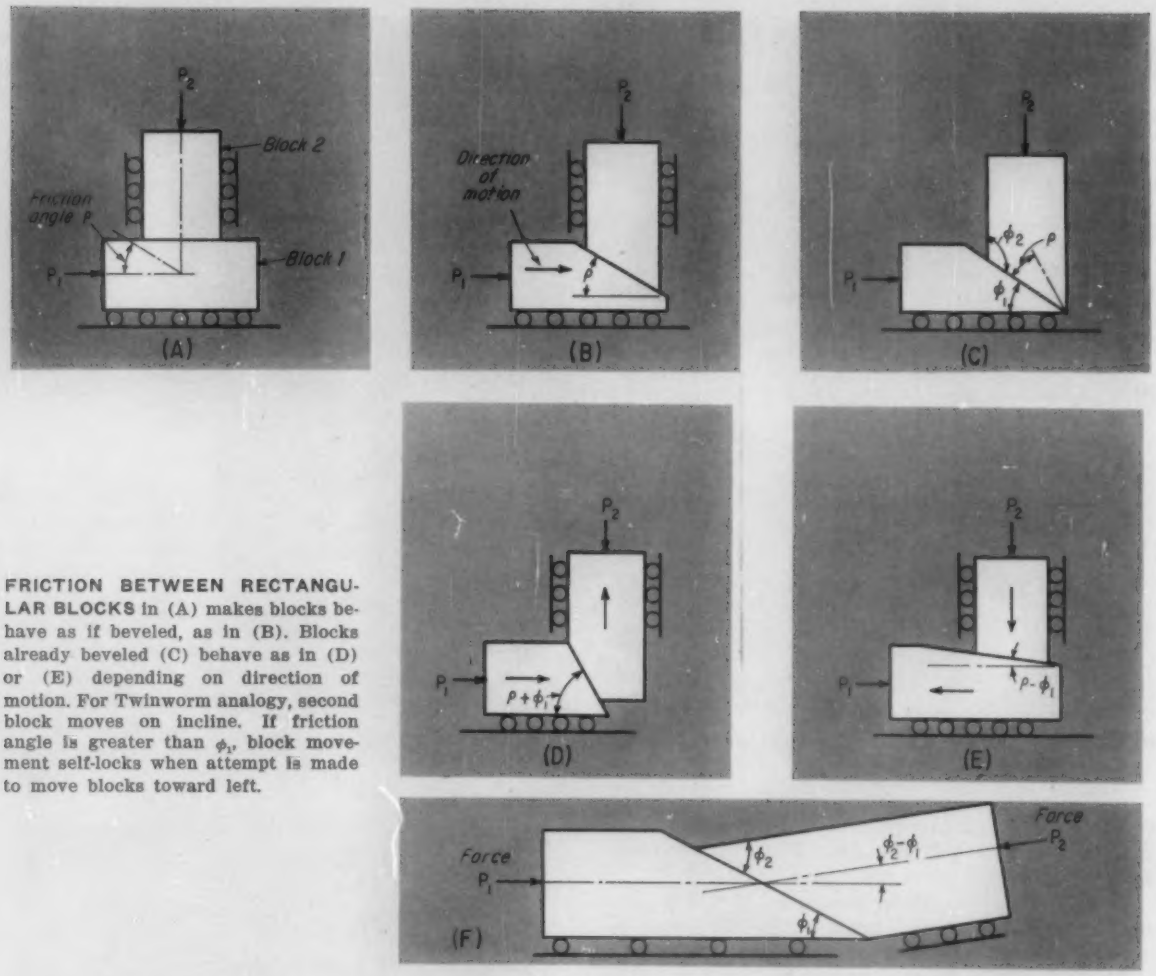
HOW THE DRIVE WORKS

Principle behind the Twinworm can best be described by analogy with sliding blocks (which actually represent portions of the gear teeth):

In diagram (A), next page, for block 1 to move to the right, it must overcome the friction between the surfaces of block 1 and 2. (The blocks are assumed to roll on bearings with negligible friction.) The resisting friction can be depicted by angle ρ whose tangent is tan $\rho = \mu$, where μ is the coefficient of friction. This is analogous to the two beveled blocks in (B) with a frictionless common surface. In other words, friction behaves as an incline plane acting against the direction of movement.

If the blocks are actually beveled as in (C), the driving block 1, can again be assumed to face a sharper incline, equal to the sum of angles ϕ_1 and ρ, as in (D). Arrows inside the blocks show direction of motion. If direction

SLIDING-BLOCK ANALOGY SHOWS SELF-LOCKING CHARACTERISTICS



FRICTION BETWEEN RECTANGULAR BLOCKS in (A) makes blocks behave as if beveled, as in (B). Blocks already beveled (C) behave as in (D) or (E) depending on direction of motion. For Twinworm analogy, second block moves on incline. If friction angle is greater than ϕ_1, block movement self-locks when attempt is made to move blocks toward left.

of motion for both blocks is changed so that block 2 is driving block *1*, angle ρ would now be added the other side of the bevel angle, ϕ_1. Thus the equivalent bevel is almost horizontal, as in (E).

If the angle $(\rho - \phi_1)$ in (E) turns out to be horizontal, or pitched the other way, block 2 cannot push back block *1*—although block *1* can push block 2. Thus if ϕ_1 is made equal to or less than ρ, the block system would be irreversible (self-locking). Variations in friction will not affect self-locking qualities as long as minimum friction values result in a friction angle of sufficient magnitude.

To simulate a Twinworm drive, the second block is depicted as moving on an incline plane, as in (F). Angles ϕ_1 and ϕ_2 represent the respective pitch angles of the two worms, and $\phi_2 - \phi_1$ is the angle between the two worm shafts (angle of misalignment). Angle ϕ_1 is quite small (usually in the order of 2 to 5°).

DESIGN EQUATIONS

Driving and opposing forces in (F) are denoted by P_1 and P_2. In his paper, coauthored with D. W. Pessen of the Israel Institute of Technology, and presented at the ASME meeting (paper no. 59-A-75), Popper shows that:

Self-locking occurs as soon as tan ϕ_1 is equal to or smaller than μ, or when

$$\tan \phi_1 = \frac{\mu}{S_1} \qquad (1$$

Here, S_1 represents a "safety factor" (selected by the designer) which must be somewhat greater than one to make sure that self-locking is maintained even if μ should fall below an assumed value. Neither ϕ_2 nor the angle $(\phi_2 - \phi_1)$ affects self-locking.

Deceleration-locking occurs as soon as tan ϕ_2 is also equal to or smaller than μ; or, if a second safety factor S_2 is employed (where $S_2 > 1$), when

$$\tan \phi_2 = \frac{\mu}{S_2} \qquad (2)$$

For the equations to hold true, ϕ_2 must always be made greater than ϕ_1. Also, μ refers to the idealized case where the worm threads are square. If the threads are inclined (as with Acme-threads or V-threads) then a modified value of μ must be employed, where

$$\mu_{modified} = \frac{\mu_{true}}{\cos \theta} \qquad (3)$$

Here, θ is the pressure angle of the thread profile—approximately 30° for V-threads and 14½° for Acme threads.

DRIVE EFFICIENCIES

Relationship between input and output forces during rotation is:

$$\frac{P_1}{P_2} = \frac{\sin \phi_1 + \mu \cos \phi_1}{\sin \phi_2 + \mu \cos \phi_2} \quad (4)$$

Efficiency for the drive is:

$$\eta = \frac{1 + \mu/\tan \phi_2}{1 + \mu/\tan \phi_1} = \frac{1 + S_2}{1 + S_1} \quad (5)$$

Shafts at right angles ($\phi_2 - \phi_1 = 90°$) present the case of an ordinary worm and worm wheel, common screw or inclined plane. Tan ϕ_1 would equal $-1/\tan \phi_2$ and Eq (5) would become:

$$\eta_{90} = \frac{1 - \mu/\tan \phi_1}{1 + \mu/\tan \phi_1} = \frac{1 - \mu^2/S_1}{1 + S_1} \quad (6)$$

where ϕ_1 is the pitch angle of the worm. For self-locking μ must be greater than tan ϕ_1, resulting in an efficiency of less than 50%.

For example, if $S_1 = 1.2$ and $\mu = 0.16$, a conventional worm drive will have an efficiency, from Eq (6), equal to 44%. A Twinworm using same values will have $\phi_1 = 7.6°$ from Eq (1). Choosing $(\phi_2 - \phi_1) = 2°$, ϕ_2 becomes 9.6° from Eq (2). This gives an efficiency of 89% from Eq (5) or twice that of the conventional worm drive.

This higher efficiency is to be expected. Efficiency losses are a function of work done by friction (friction force × displacement). In Twinworm diagram (F), there is very little sliding motion between surfaces of the blocks. With ordinary worm gears, the blocks would be at right angles, as in (C), and relative sliding is high, resulting in low efficiency.

POWER REQUIREMENTS

As mentioned previously, a Twinworm can be designed so that the same torque is required for raising or lowering a load. This condition occurs when

$$S_1 = 1/S_2 \quad (7)$$

Substituting this relationship into Eq (5) gives the efficiency of the drive to meet this condition:

$$\eta = S_2 = 1/S_1 \quad (8)$$

If, however, it is more important to raise and lower the load with minimum power consumption for one complete cycle, then

$$S_2 = S_1 - \sqrt{S_1^2 - 1} \quad (9)$$

The power required for raising the load will no longer equal the power to lower it, and a larger power unit will be needed than in the previous case. Over-all power consumption will be lower, however, and equal to:

$$E = \frac{Wh}{S_2} \quad (10)$$

where E = energy required per cycle, and h = height that load W is to be raised and lowered.

EXAMPLE OF TWINWORM DESIGN

Problem: Design a Twinworm for self-locking with a step-up speed ratio of $n_1/n_2 = 1.5$. It must be able to raise or lower a load with the same torque input so that the hp requirement of its motor is kept to a minimum. Coefficient of friction, modified by the type threads employed, as per Eq (3) is $\mu = 0.15$. A 20% safety factor is chosen: Therefore $S_1 = 1.2$.

From Eq (1)

$$\tan \phi_1 = \frac{0.15}{1.2} = 0.125; \phi_1 = 7.1°$$

From Eq (7)

$$S_2 = \frac{1}{1.2} = 0.833$$

From Eq (2)

$$\tan \phi_2 = \frac{1.5}{0.833} = 0.180; \phi_2 = 10.1°$$

Angle between shafts is $10.1° - 7.1° = 3°$

From Eq (8)

$$\eta = \frac{1}{1.2} = 0.833 = 83.3\%$$

Relationship between speed ratio n_1/n_2 and pitch diameters of the worms, D_1 and D_2, can be shown to be:

$$\frac{D_1}{D_2} = \frac{n_1}{n_2}\left[\frac{\sin \phi_2}{\sin \phi_1}\right] \quad (11)$$

Therefore

$$\frac{D_1}{D_2} = 1.5\left[\frac{\sin 10.1°}{\sin 7.1°}\right] = 2.14$$

Selection of the pitch diameters can then be made, based on strength and other considerations.

Problem: Design the drive for deceleration-locking. Here S_2 is selected first. Assume $S_2 = 1.2$ and $\mu = 0.15$, then from Eq (2):

$$\tan \phi_2 = \frac{0.15}{1.2} = 0.125; \phi_2 = 7.1°$$

This time a wide choice is available for ϕ_1. It can be shown that the ratio of sliding to peripheral velocity is:

$$R = \frac{\phi_2 - \phi_1}{\phi_2} \quad (1)$$

From past experience, a ratio of 0.3 has been found to be low enough to avoid much sliding and wear, but high enough to insure positive locking.

Hence:

$$\phi_1 = 7.1° - 0.3\,(7.1°) = 5°$$

From Eq (1)

$$S_1 = \frac{0.15}{\tan (5°)} = 1.72$$

From Eq (5)

$$\eta = \frac{1 + S_2}{1 + S_1} = \frac{2.2}{2.72} = 0.809 = 80.9\%$$

From Eq (11)

$$\frac{D_1}{D_2} = 1.5\left[\frac{\sin 7.1°}{\sin 5.0°}\right] = 2.13$$

EDITOR'S NOTE: Patents have been applied for on the Twinworm drive by B. Popper. For further technical or licensing details, one can contact in this country: Helmut Pessen, 4652 N 11th St, Philadelphia 40.

Helical gears were recently paired with spur gears in a standard planetary system, resulting in fantastically high speed reductions. For details see: Novel Concept Gives Record Gear Ratios, June 22 '59, p 67.

Superalloy spring of NS-25 (L605) at left stays good as new after several hundred cycles at 1100 and 1400 F. Spring of ordinary stainless (right) is completely deformed after one cycle. The comparison illustrates why springing-stability is more important than high strength when choosing . . .

the best SPRING MATERIAL for HIGH TEMPERATURE

V A STANTON, *chief metallurgist, National-Standard Co*

As temperatures go up, a spring tends to relax. Moreover, there are no handy equations to guide you to the best spring material for such service. This is why we tackled the problem empirically, in terms of the material for coil springs. The approach was to select from more than 100 alloys suitable for temperatures above 400 F—ranging from tool steels through the stainless steels and superalloys. Then we compared stability—ability of the spring to maintain a constant or predictable length and load.

Result is this guide, with accompanying comparison tables. In general, the age-hardenable alloys work out best. The higher the aging temperature, the better stability. Besides avoiding permanent set, age-hardening has the advantage of relieving stresses built-in by coiling.

This comparison deliberately overlooks ultimate tensile strength at the higher temperatures. This is because, as temperature rises, stability becomes more important. And the cold drawing, which increases room-temperature strength in spring wire, now detracts from stability.

The Materials by Groups

Spring materials for service above 400 F can be divided into these groups:

• **The ferritic alloys.** These mainly are modified 5% Cr tool steels, low in cost and alloy content. Low alloy makes them somewhat more stable at about 400 F than carbon steels. They have good oxidation resistance up to 1000 F but do not compare in corrosion resistance with the other hi-temp alloys. Quench-hardening is the way to build up their strength. This means the coils must be wound while the material is soft, then quenched and tempered for maximum physical properties. But such heat treating increases costs and the resulting distortion limits usefulness of the spring.

• **Ferritic-austenitic stainless steels.** Their composition includes about 17% chromium and 7% nickel. These steels are primarily austenite, with some ferrite. They are hardened by aging or by a combination of subzero freezing followed by age hardening. Examples of these steels are 17-7 PH, which has been used up to about 600 F, and the newer PH 15-7 Mo.

• **Completely austenitic stainless steels.** An example is A286, precipitation-hardenable at about 1300 to 1400 F. Such steels are cheapest of the so-called superalloys. Their relatively high aging temperature approaches performance of the next group.

• **Nickel-base alloys.** Best known is Inconel X. It has become a standard for the hi-temp springs because it furnishes readily available design data. The quality is uniform and properties are predictable. For jobs about 1000 F, designers should first consider Inconel X before going to other, more expensive "exotic" materials in the next two groups.

• **The Ni-Cr-Co alloys.** These have proved themselves in hi-temp structural applications. Because they retain high strength along with stability, they have shown promise for spring service at 900 to 1200 F. Rene 41, a vacuum-melted version, shows possibilities better than those of Inconel X and NS-25.

• **Cobalt-base materials.** One of them, NS-25 (L605), is being used in springs from 400 through 1400 F. Also showing spring possibilities is S816, which contains molybdenum and tungsten.

Processing for Better Performance

Nature of the alloying elements determines whether to melt the spring material in vacuum or in air. Some alloys such as Rene 41 can only be made in vacuum, so cost runs higher. Some other alloys have better fatigue strengths at room temperature after vacuum melting. But at high temperature where loads have to be lower, vacuum melting usually does not pay.

Other materials are notch-sensitive and have to be ground after melting and drawing. They crack during cold drawing if defects are not removed. This increases cost because appreciable metal (0.010 to 0.040 in.) may have to be ground off.

Processing needs are also dictated by nature of the application. A spring operating at room temperature and a high stress level might fail from a lowered endurance limit caused by surface cracks. At 600 F or above, maximum stresses are determined by creep limits. Springs are not affected by small cracks ranging from 0.001 to 0.005 in. deep.

Lubricants provided for automatic coiling, when left on the wire during heat treating, usually do not affect stability or strength. If desired, however, they can be removed by dipping in nitric acid. Higher temperature stress-relief and aging above 1000 F require a protective atmosphere to prevent formation of scale. Although excess scale can be removed by vapor blasting, this usually changes cross-section of the spring and therefore its performance.

How to Decide

To choose an alloy one must first determine these operating conditions (1) stress; (2) temperature; (3) time at temperature; (4) cycling of temperature and stress; (5) stability required; (6) resistance to corrosives in the atmosphere.

1. Higher stress requires a higher grade of alloy. Stress can sometimes be lowered by increasing cross-section. Although lowering stress can permit substitution of a cheaper material, some materials have a temperature limitation—beyond this point, they are unsuitable even with low stresses. Also, there are other practical limitations on space and weight.

2. Higher temperatures and longer time at temperature call for better grade of material.

3. Stability can be expressed in percentage of the initial spring force that the spring is allowed to lose. For more stability, choose the better alloy. For example, an application that allows a 2% change in load requires a more stable material than one where the spring is still satisfactory after a 15% relaxation.

4. Corrosive atmospheres under 1000 F usually do not alter the spring material itself. Above 1000, ferritic alloys lose their strength when oxidizing atmospheres decarburize the surface; austenitic alloys become embrittled by carburizing atmosphere; nickel alloys, though unaffected by reducing atmospheres, become brittle even when small amounts of sulfur contaminates are present. Actually, most hi-temp springs are shielded from combustion atmospheres and the effect of the altered surface layers are less at high temperatures because of lower design stresses in such springs.

A practical way to choose an alloy is to compare the proposed materials with one already serving in a similar

HOW THE ALLOYS RANK

	For Hi-temp Stability	For Economy (times cost of 302 stainless steel)
1.	Rene 41	17–7 PH (2x)
2.	S816	PH 15–7 MO (2.5x)
3.	NS–25	A286 (3x)
4.	Inconel X	Inconel X (7x)
5.	A286	Rene 41 (25x)
6.	PH 15–7 MO	S816 (30x)
7.	17–7 PH	NS–25 (40x)

STABILITY OF ALLOYS AT 600 F

Alloy	Temper	Hardening Treatment	Relaxation after 100 hr at 600 F, % Shear stress, psi 20,000	40,000
17–7 PH	Spring	1 hr 900 F	...	2.8
17–7 PH	Spring	16 hr 900 F	2.5	2.6
17–7 PH	30%	16 hr 900 F	2.5	3.2
17–7 PH	15%	16 hr 1000 F	2.5	3.0
PH 15–7 MO	Spring	16 hr 900 F	1.0	1.0
PH 15–7 MO	30%	16 hr 900 F	1.5	1.8
NS-25 (L605)	30%	16 hr 900 F	...	0.3
Inconel X	15%	16 hr 1350 F	0.7	0.5

application. Then use table at left—giving temperature-stability ranking and the relative cost—to narrow down the materials to test. For example, if 17-7 PH is being used and more stability is required in the same general price range, PH 15-7 Mo or A286 should be tested. If the present material is Inconel X, and a lower cost is wanted, A286 or PH 15-7 Mo may fill the bill if stresses are low or some stability can be sacrificed.

This rating for high-temperature stability is only a general guide. Under certain specific conditions, A286 is superior to all the others; for other conditions, NS-25 is best.

Economy rating of the spring alloys is given in increasing order of price compared with 302 stainless wire. These vary somewhat in a range depending upon the size of the wire required as well as for the application itself. For example, for short-time service, Inconel X and higher alloys need not be ground, thus lowering their cost considerably.

Generally, Inconel X is a good starting point because hot-spring data is most complete for this material. Also, its temperature span cuts across the entire gamut from 600 to 1400 F and it is much cheaper than the next

ELEVATED-TEMPERATURE RELAXATION

(of Inconel X, helical-coil springs: No. 1 temper—15% cold reduction—aged 16 hr at 1350 F)

Temperature, °F	Shear Stress, psi	Relaxation, % 1 hr	72 hr	340 hr	500 hr
800	20,000		1.5	1.6	1.6
	40,000	0.2	1.5	2.1	2.0
	50,000	0.2	1.8	2.5	2.5
	60,000	0.3	2.0	2.8	3.0
	70,000	0.3	2.2	3.0	3.2
1,000	10,000	1.2	3.4	4.2	4.2
	20,000	1.2	3.7	5.2	5.3
	30,000	1.2	3.1	4.4	4.6
	40,000	1.2	3.6	4.9	5.1
	50,000	1.2	4.4	6.0	6.4
	55,000	1.9	6.4	7.9	8.3
	60,000	2.5	6.4	7.9	8.3
	70,000	2.8	9.2	10.7	10.9
1,100	10,000	1.2	5.3	8.5	9.0
	20,000	1.2	4.8	7.3	8.0
	30,000	1.2	5.3	8.3	8.8
	40,000	1.2	5.2	7.8	8.5
	50,000	2.0	7.0	10.3	11.5
	55,000	2.8	8.3	11.8	13.2
	60,000	2.9	9.4	13.3	14.9
1,200	10,000	1.8	8.3	15.8	18.8
	20,000	2.4	10.3	17.8	20.8
	30,000	2.4	9.6	17.0	20.1
	40,000	2.6	13.0	22.3	26.0
	50,000	3.5	14.5	24.0	28.0

class of exotic superalloys. These, in wire form, sell for as much as $30 to $50 per pound.

Selection of Alloy Temper

The full-hard spring temper normally specified for spring materials is not the best for maximum stability at high temperatures. For temperatures below 450 F, best choose the highest tensile strength for maximum load-carrying. As temperature rises, design stresses must be decreased to avoid excessive creep. Cold working lessens stability under heat, but is preferred at lower temperature because it increases tensile strength. But there will be a temperature where the advantages of more cold working and less cold working will have to be weighed. For example, at 600 F 17-7 PH with spring temper is more stable. At 650 F the 30% reduction is better. PH 15-7 Mo with less cold work becomes more stable at 700 F. Keeping the design stresses below the yield point also gives more stability. Annealed material that is precipitation hardened has better stability at high temperatures.

RECOMMENDED TEMPERS

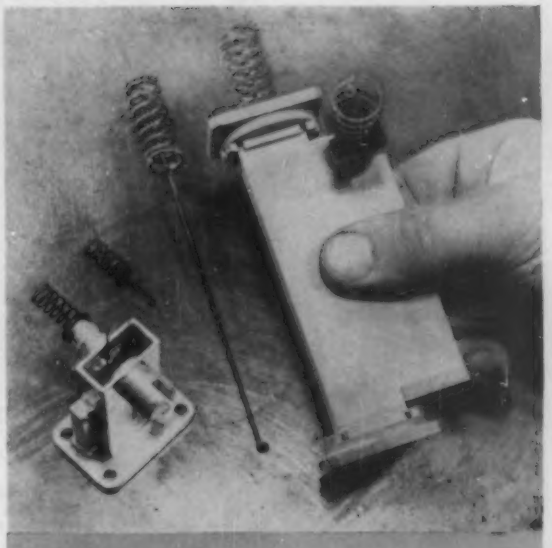
Operating temperature, °F	Alloy, %, reduction
300–600	Spring temper or 30%
600–900	30% or 15%
over 900	15% or annealed

Overaging—aging at higher temperatures than normal—is another way to try to increase stability, even though it may lower other properties to an even greater extent. Sometimes, in an alloy that needs only slightly more stability, the simplest way is to try increasing the aging treatment by 100 to 200 F.

The tests described above were at a given temperature. But the preferred order for stability may change with temperature. For example, NS-25 tends to be better than Inconel X at higher temperatures, but at 600 F it is less stable. Therefore, if temperature fluctuates, it would be important to know the proportion of time at high and low temperatures.

Moreover, the tests were at relatively short time, and relaxation was measured at room temperatures after exposures to high temperatures—therefore can only help predict long-time performance. Because the austenitic A286 takes a fairly large initial set, its short-time performance does not predict good long-time properties. But once it takes an initial set, the amount of relaxation levels off and under certain conditions can be less than that of Inconel X or NS-25.

FOR REPRINT of above article, just check P 30 on one of the Reader Service cards bound in this issue.



Stability is often needed even when the spring will not be incorporated in final assembly. Hi-temp springs pictured here provide accurate alignment during brazing.

EDITOR'S NOTE: How well a chosen spring material will absorb energy depends upon its shape. For additional design information, see:

Your Guide to Springs that Store Energy Best, Nov 10, '58, p 71. Tables and equations compare 13 spring shapes for best energy absorption.

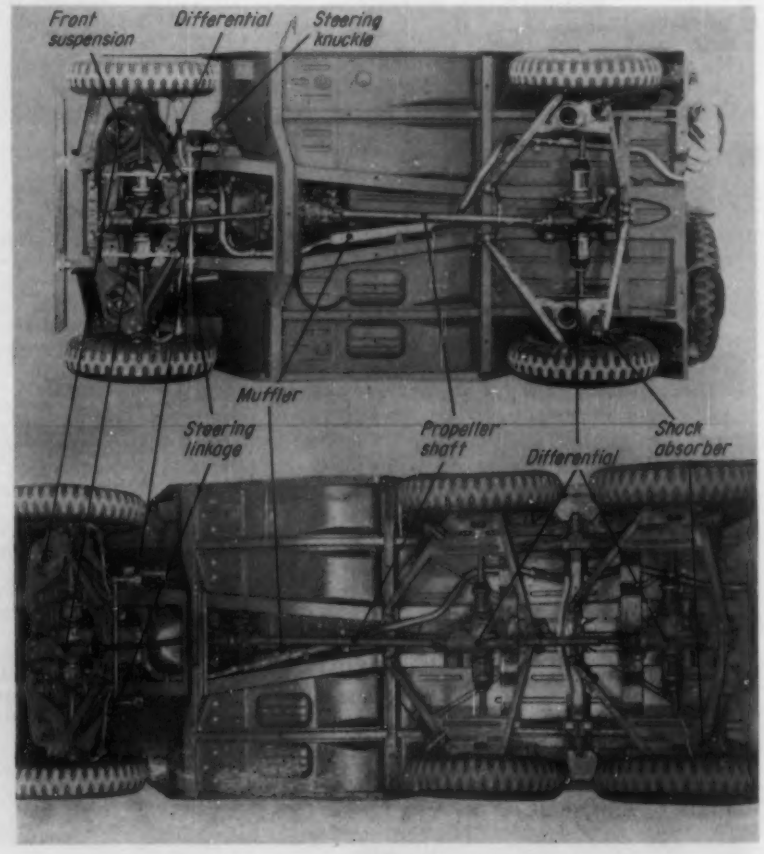
How to Design Multi-rate Helical Springs, Jan 20 '58, p 76. When constant stiffness of a helical spring is a disadvantage, springs can be assembled in series to give a rate that varies.

Helical-spring Design Chart Gives Quick Answers for Steel Springs, Jan 19 '59, p 93. When you know deflection rate, total load, max stress, and coil dia, this handy nomograph gives answers for wire dia, number of coils, deflection.

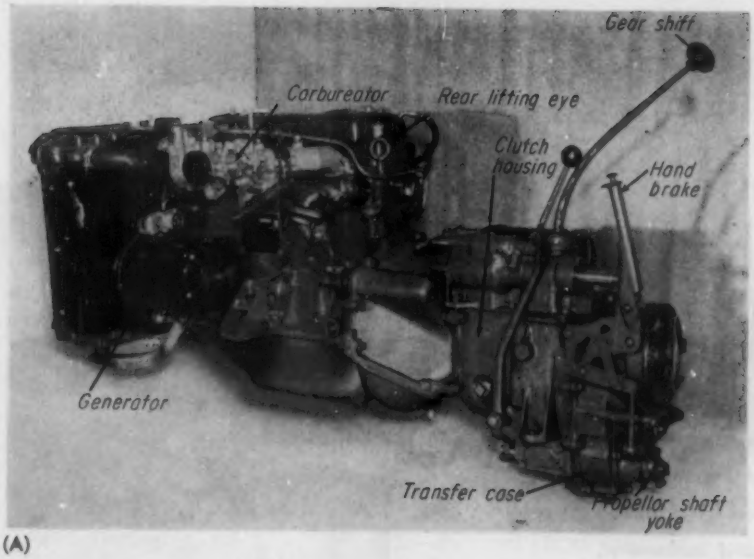
How Much Force to Deflect a Spring Sideways?, Jan 5 '59, p 71. Formulas give force and stress when a lateral load deflects a vertically loaded spring.

Interchangeable Parts Breed Family Of Army Vehicles

The design concept here counts on common components to reduce problems of production and supply, and speed maintenance in the field. Photos give two views of the jeep-style ¼-tonners.

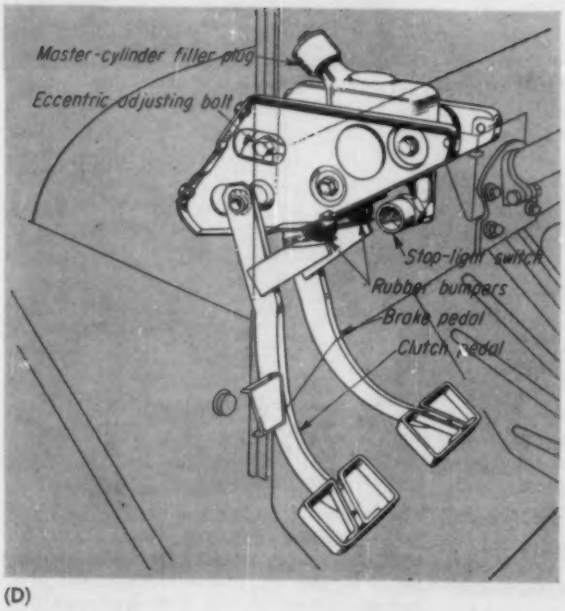


Worm's-eye view . . . of ¼-ton M-151 and ¾-ton M408 shows large number of interchangeable parts. These include the entire front suspension which may be removed as a unit—also the differentials, steering linkage, springs, A-frames, half-axles, universal joints. Other interchangeable parts include the propeller shaft, wheel hubs, steering knuckle, shock absorbers, mufflers, brakes, and all body sheetmetal forward of the rear wheels. Principal differences are tires, ring and gear sets for differential, and the use of leaf springs in the M408 rear suspension of the vehicle.

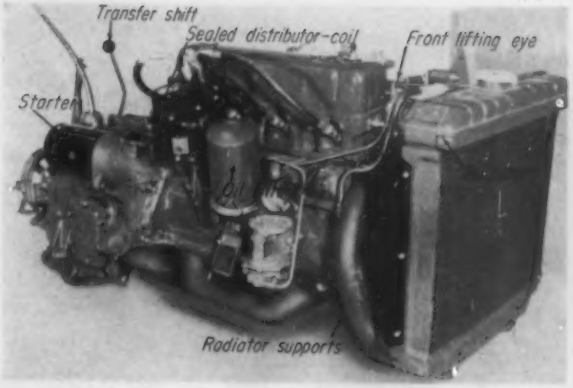


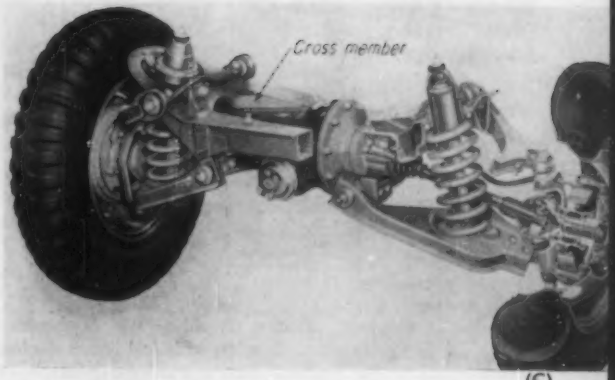
(A)

(B)



(D)





(C)

Package concept . . .
for easier field maintenance is demonstrated here (A) & (B) by power pack consisting of radiator, engine, transmission, and transfer case. A separate assembly comprising these units may be replaced, using standard tools, in 35 min. in the field. Quick-disconnect fittings and large access plates permit the power pack to be disconnected rapidly and lifted out of the vehicle.

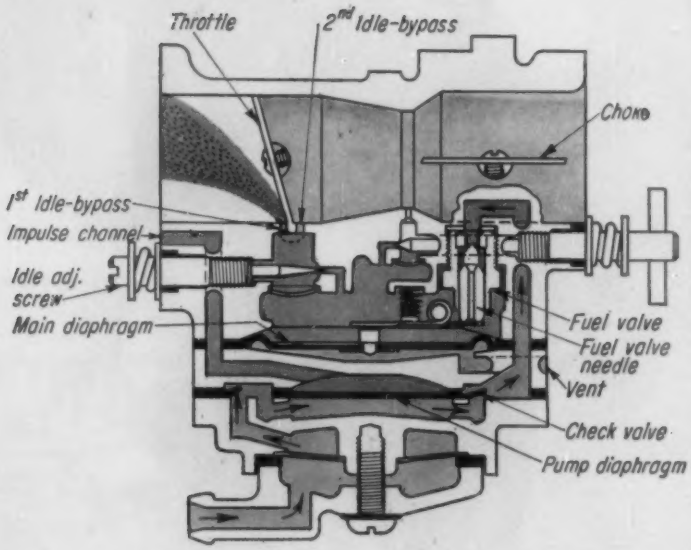
Front-end package (C) is based on box-sectioned crossmember which mounts all suspension parts, the differential, and the wheel driveshafts. The crossmember is connected to body brackets welded to the side rails by 16 bolts and nuts. Other suspension features which ease supply problems include interchangeability among: all wheel-spindle bearings, brake shoes and drums, front-axle shafts or rear-axle shafts, and rear-spindle supports.

Service brake package (D) consists of a hydraulic master-cylinder mounted in a bracket under the dashboard. Suspended pedals for brake and clutch are mounted on the standard bracket.

PS. . . First of a new group of heavy-duty military vehicles, M-151E1 and M-151E2 are ¼-ton 4 x 4 passenger and cargo vehicles. Approximately 85% of the ¼-tonner's service parts can also be used in the ¾-ton 6 x 6 and 1-ton 8 x 8. Aluminum body of the E2 model reduces the dry vehicle's weight 262 lb to 1811 lb. Bodies were designed so that either aluminum or steel stampings can be produced from the same dies. Nicknamed "MUTT" (Military Utility Tactical Truck) the vehicles are produced by Ford with the help of approximately 65 subcontractors. For more on the program, see PE—Sep 21 '59, p 21.

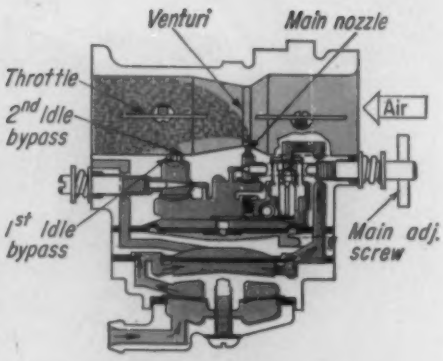
Dual Diaphragm Simplifies Fuel System

By doing away with the conventional float mechanism it allows holding this chain saw at any angle. Gasoline is fed by a unitized combination of fuel pump and carburetor.



Idling occurs . . .
when throttle is closed. Suction on engine side of throttle draws air down through the 2nd idle-bypass. It mixes with fuel and is discharged through the 1st idle-bypass to the engine. Engine crankcase pulsation, which reach the pump through the impulse channel, actuate the pump diaphragm. This draws fuel up through the strainer screen. A check valve at each side of the pump chamber restricts fuel flow to one direction. Fuel passes through inlet supply channel to the fuel valve.

Meanwhile, pressure in chamber surrounding the fuel valve is lowered as fuel is discharged through the first idle-bypass hole. Atmospheric pressure on lower side of the main diaphragm causes it to rise, lowering the fuel-valve needle and replenishing the gasoline supply. When chamber is filled, the diaphragm lever spring closes the fuel valve. The idle-adjusting screw controls engine idling speeds.



Saw operates at full power . . .
when the throttle is wide open. This creates a partial vacuum in the carburetor bore and causes fuel to discharge through both idle-bypass holes and also the main nozzle—providing the maximum volume of fuel-air mixture for maximum power. The main adjusting screw supplies the precise setting required for the best air-fuel ratio.

PS...Besides allowing all-position sawing, the balanced-diaphragm system reduces fire hazards—without gravity flow of fuel there is less chance of gasoline spillage. The 2-cycle chain saw is produced by Pioneer Saws, Waukegan, Ill; the fuel system is produced by Brown Engine Products, Danbury, Conn.

7 steps to better oral reporting

E J TANGERMAN,
editor

step 1: From ideas to outline
step 2: How to organize a talk
step 3: Now you need notes
step 4: Hints on delivery
step 5: Platform manners
step 6: Chairing committee or panel
step 7: Chairing a meeting

2 . . . Organization is the key

Basic structures of a speech and a written report are the same—the principles have already been covered in "Eight Steps to Better Report Writing" in PRODUCT ENGINEERING (reprint available on request). It is essential in both to be simple for clarity. Don't try to impress your hearers with pompous, pedantic language; you'll end up mentally muscle-bound. Beware of the "scientific style," but suit the approach to the occasion.

Let's try this for size. Here are some facts:

Archimedes, entering his bath, sees it overflow and realizes that a body immersed in a fluid displaces its own volume. Thus he has found a way to test the genuineness of gold in the king's new crown. (Archimedes' actual report, delivered nude at a dead run, was "Eureka!"—I have found it.)

See if you can do better, starting a speech to: (1) his wife, (2) the king, (3) the people, (4) shipbuilders, (5) engineers, (6) mathematicians.

Our solutions: (1) I am sorry I flooded the bathroom, dear, and ashamed that I ran naked through the streets. But, you see, the king gave me a problem I couldn't solve and I was afraid we'd lose our contract. But I've just figured out a way to solve it, thank Zeus . . .

(2) O mighty Hieron, king of Syracuse, thou in thy wisdom hath been right. The goldsmith hath indeed cheated thee. Thy crown has been cheapened with silver, and I can prove it . . .

(3) Your king has been cheated by the goldsmith Oelon, who has mixed silver with the gold in his new crown. Hieron, the All-Seeing, suspected this and ordered me to devise a test. This I have done . . .

(4) You have used my screw to dewater your ships, my burning-glass to fire the Roman galleys, my lever to move a laden caravel by hand. Thus you know I speak truth when I say that these mechanisms have but little importance beside a basic scientific discovery by which I can weigh ships, with and without cargo . . .

(5) Volume of an irregular object, as well as its composition, can be determined by two new hydrostatic principles which I shall demonstrate. The principles are: (1) A body immersed in a fluid displaces its own volume; (2) a body immersed in a fluid loses as much weight as an equal volume of the fluid.

(6) To determine the volume of an irregular object, immerse it in fluid. The volume of fluid displaced will be that of the object, $V_1 = V_2$. Further, the body will lose as much weight as an equal volume of the fluid, thus: $W_a - W_s = W_f$.

It's a matter of organization, as you can see. Opera-lover or not, remember the title AIDA: Attention, Interest, Desire, Action. This is a good structure for any talk—technical, sales or social.

Attention: Make a simple statement of your subject that will show how the audience will benefit by listening (note the preceding examples). This can be a single sentence, shouldn't be more than a paragraph, even if you're a story-teller. Beware of the "I am reminded of a story . . ." techniques of the old vaudevillian and after-dinner speaker; *they* don't do that any more.

Interest: Ask rhetorical questions that you are going to answer; promise the listener, directly or indirectly, that he'll gain by listening; show him how *he* personally will benefit. This is the "bridge" that connects introduction and body of your speech, talk or paper.

Desire: Arrange your points so the listener is impelled to do what you want: believe you, follow your lead or whatever. This section must be connected in thought; the listener can't go back or look ahead as the reader can. Sum up each idea as you go along and show its connection to the next one. Follow the old preacher's admonition: Tell 'em what you're going to tell 'em, then TELL 'em, then tell 'em what you told 'em.

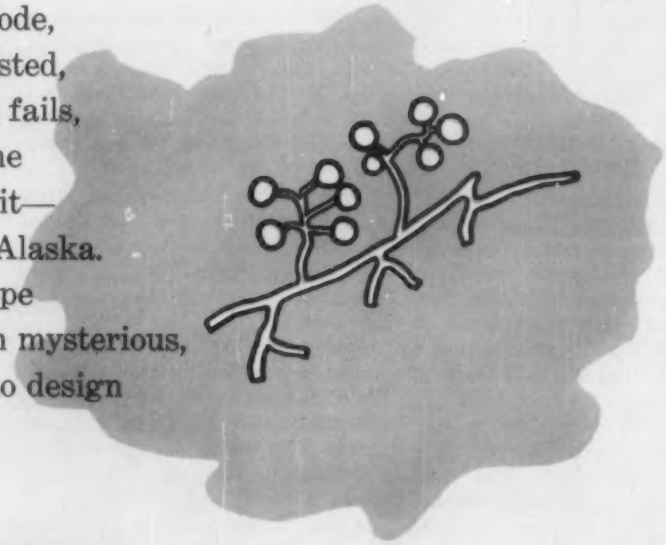
Action: This is the summary, and should be short. In a technical paper, it will consist of subordinate conclusions leading to the main one. In other talks, it may be the "sales pitch," the final statement of what you want the audience to do or believe. It should be simple, positive, introduce no new ideas.

Lastly, be human. Life is never a logical series of steps to a perfect conclusion. Your presentation should include at least a little of the frustrations, the wrong starts, the tries that failed. That makes you human, just like your listeners, who have their frustrations and troubles too. Show what other avenues have been explored, thus how thoroughly proved your result is. Never forget the virtues of the parable or case study that Jesus and Lincoln used so effectively to convey their personal messages in memorable form. The anecdote, and colorful words and phrases, have their place too: "fourscore and seven" instead of "eighty-seven," for example.

You now have a paper. Next week we convert it into a speech.

***A reprint will be available** including all seven lessons in this series. To get your copy, circle P42 on Readers Service Card.*

When metals corrode, lenses become frosted, electrical insulation fails, fungi may be the unsuspected culprit—even as far north as Alaska. Here's how to cope with this serious, often mysterious, challenge to design



FUNGI are your product problem

ANNESTA R GARDNER, *associate editor*

Fungi are tiny, parasitic molds that are not just a tropical problem. They are a serious product hazard in temperate zones as well.

But designing products to resist fungus damage is a complex matter. A lot of complaints about "rusted metal," "discolored finishes," and even "scratched" glass could be eliminated if the real cause—fungi—were recognized. But, there are upwards of 10,000 kinds of fungi—and 10,000 ways to deal with them.

The Parts They Attack

The extent of the mold-and-mildew problem is indicated by a rundown of parts and materials susceptible to fungicidal action. The Signal Corps, for instance, has listed more than 150 of them, including capacitors, sockets, soldered joints, terminal boards. Furthermore, the Signal Corps finds, "under the proper conditions of humidity, temperature, and pH, fungi may grow on almost any surface.

"It has been demonstrated that, under proper moisture conditions, fungus spores which are present on clean glass are able to grow sufficiently to be troublesome by using only the stored food which is present in the spores. In addition, their products of metabolism may etch glass surfaces."

Where FUNGI Can Grow

Fungi can be a serious problem in all of the areas outlined above, from Southern Mexico up to Alaska in the west and to the St Lawrence region in the east. What kind of problem? . . .

. . . **In Philadelphia,** Navy tests showed a lowering in the electrical insulation resistance of stored vinyl sleeving though there was no apparent change in the material itself.

. . . **In Seattle,** aircraft groups reported trouble with clogged fuel filters, though the fuel itself had been carefully filtered before use and, to all appearances, was thoroughly clean.

. . . **Last summer, New Yorkers** found their radios sputtering and dying though tubes and circuits seemed good.

A few years ago, perhaps all these would have been attributed to design or manufacturing errors, to misuse, accelerated injury, or some other "mysterious" cause. But, in every case, the trouble was traced to fungi.

It is true that fungi do not usually become a serious problem unless there is at least a moderate amount of heat and humidity. But "heat" and "humidity" are relative terms. **The area in which fungi can and do constitute a problem extends all the way from the tropics to Alaska (see map).**

The optimum temperature for fungus growth is 60 to 85 F; but fungi have been found growing at temperatures as low as 35 F and as high as 125 F. Fungus spores ("seeds" from which fungi grow) will stay alive at even lower and higher temperatures, though the fungi won't actually flourish. **But they're ready to spring into action the minute the right conditions appear. They'll exist in a vacuum too; and are so small they defy detection.**

The Design Answer

What, then, can be done about fungi? Basically, there are three approaches:

1. Eliminate anything on which they might feed.
2. Apply fungicidal treatments.
3. Seal the product to keep out moisture.

The first is always a desirable goal, but rarely a fully attainable one.

The second is an aid rather than a complete solution, and may have undesirable side-effects.

The third, hermetic sealing or encapsulating, is effective, but limited in application. When it can be used, it has virtually eliminated the need for fungicides. **The Signal Corps, for instance, now specifies hermetic sealing in preference to either of the other approaches; and such small components as capacitors and potentiometers present little or no fungus problem today.** But for larger items—and for the housings which enclose the sealed components, the straps by which they are suspended, and the tapes and charts used for recording data—this solution is not possible and the other approaches must be considered. It's not an easy job.

Materials which start out fungus-resistant may be made fungus-prone by treatments during processing.

Materials completely inert to direct attack may be at-

MAGNETIC TAPE LOOKS LIKE THIS after six months' exposure to warmth and humidity. Fungi have almost completely destroyed the tape backing, producing a thick, puffy mass that bears almost no resemblance to the original material. It's typical of the damage these parasitic plants can cause.

tacked indirectly by fungus-produced by-products.

Fungicidal treatments may alter physical and electrical properties, particularly since many of them contain metallic elements which may considerably alter the electrical insulating abilities of dielectrics. Furthermore, compounds which kill fungi or inhibit their growth when used alone, may be totally ineffective when incorporated in other materials. **Many of the "best" fungicides, too, are volatile materials that lose their effectiveness in a relatively short time.**

Speaking of organic coatings for printed circuits, Benson G. Brand of Battelle Memorial Institute says:

"The fungus does little actual physical damage to the coatings. But it tends to limit their dielectric properties by encouraging the retention of moisture on the surfaces and itself serving as a conductor.

"Some measure of protection against such growth has been achieved by incorporating, into the coating film, compounds such as phenyl mercury oleate that are toxic to the fungi. However, these materials tend to lose their effectiveness gradually, thus only delaying development of the fungi and the almost inevitable malfunctioning of the electrical circuit."

For all these reasons, a mere listing of available fungicides has little value in product design. **The best answer is to specify a fungus-resistant material and then test it as it is used.** DuPont, for instance, now offers a special mildew-resistant enamel. Borden Chemical Co has fungus-resistant and vinyl insulation sleeving. Bourns Inc has a full line of fungus-resistant potentiometers.

However, even though you may not specify a particular fungicide, it's a good idea to be familiar with at least a few of the more important names.

The best-known fungicide is copper-8-quinolinolate. It came into prominence during World War II and is still widely used on textiles and on a good many other non-electrical products.

Other frequently used compounds include salicylanilide and chlorinated phenols.

Coming up are a number of organometallic compounds (*PE—July 21 '58 p 18*); among them, the tributyl tins. The tin compounds are particularly interesting because they seem effective in a wide range of materials.

But none of these can be considered the "perfect" or final solution.

Terms you'll want to know

Fungus: a parasitic plant which contains no chlorophyll and so cannot make its own food but must live on other materials.

Funginert: a material which definitely does not supply the materials necessary in fungus growth. Metals, glass, and most basic resins fall in this category.

Fungus-resistant: a material which does not, under most conditions, support fungus growth, either because it is funginert or because of some fungicidal treatment.

Fungus-susceptible: a material which will, in some cases at least, supply the necessary nutrients for fungus growth. Materials such as paper, leather, castor oil, and wood, fall in this category.

Fungi-stat: a material which inhibits fungus growth.

Fungicide: a material which kills fungi.

The Gaps to Be Filled

Perhaps the best indication of the current status of fungicide development is the fact that the current list of *Inventions Wanted by the Armed Forces* includes almost a full page on fungicides, and makes the following flat statement:

TERMINAL BLOCK from radio set sports heavy fungus beard after two months' exposure to optimum fungus-producing conditions. Even when growth itself does little harm, it can deposit organic materials that may result in electrical arcing and tracking. This is a Bell Telephone Lab photo.

"No fungicide is available that is colorless, compatible with other components of a finish, stable to chemical change and actinic radiation, resists leaching, is nontoxic to humans, and economical both with regard to effective concentrations and cost."

Furthermore, says the report, "New test methods are needed to determine the efficacy of fungicidal treatments. None of the test methods presently available adequately determine evenness of deposition of fungicides to ensure that all areas are thoroughly impregnated with the fungicides."

Still, despite all the unanswered questions, there are ways to get around the fungus problem, and ways to test their effectiveness. For a quick survey of fungicide requirements and test systems, a good place to start is with such military specifications as: MIL-F-13927 (Ord), Fungus Resistance Test, Automotive Electrical Components; MIL-E-5272, Environmental Testing.

Design Checklist

Then, check your design for points like these:

- Choose materials with low moisture absorption whenever possible since these, in general, are less subject to attack. They do not carry humidity with them.
- Use hermetic sealing whenever possible, but make sure that the sealing area is kept to a minimum to reduce danger of leakage.
- Where hermetic sealing is not possible, consider use of gaskets and other sealing devices to keep out moisture—but be sure they do not contribute to fungal activity; and watch out for "breathing" that may admit moisture.
- Try impregnating or encapsulating materials with fungus-resistant hydrocarbon waxes and varnishes.
- Be careful about placing corrodable metal parts next to treated materials; and watch glass and metal parts placed between materials that might support fungal growth and deposit corrosive waste products as they grow across the gap.
- Where treated materials are used, make sure they do not contribute to corrosion, or alter electrical or physical properties.

It's a big problem; but one that can be solved—and the **biggest step towards solving it is recognizing that it exists.**

FOR REPRINT of above article, just check P 29 on one of the Reader Service cards bound in this issue.

Where to get help on fungus control

There are more than 10,000 fungicides and over 100 companies produce such compounds commercially. Most, however, concentrate on agricultural, wood, and textile applications. Among those which supply industrial fungicides, and are developing new ones, are these:

Advance Solvents & Chemical, New Brunswick, NJ.
Allied Chemical & Dye Corp, 42 Rector St, NYC.
Antara Chemicals, 435 Hudson St, New York 14.
F W Berk & Co. Inc., Park Place East, Woodridge, NJ.
Buckman Labs Inc, 1256 N McLean St, Memphis 8.
Dow Chemical Co, Midland, Mich.
E I du Pont de Nemours & Co, Wilmington 98, Del.
Gallowhur Chemical Corp, N Water St, Ossining, NY.
Koppers Co Inc, Wood Preserving Div, Orrville, Ohio.
Metalsalts Corp, 200 Wagaraw Rd, Hawthorne, NJ.
Metal & Thermit Corp, 200 Park Ave, New York 17.
Monsanto Chemical Co, Organic Chemicals Div, 800 N 12th Blvd, St Louis 1, Mo.
Norton Chemical Works, 45 N Broad St, Ridgewood, NJ.
Nuodex Products Co Inc, 802 Magnolia Ave, Elizabeth, NJ.
Onyx Oil & Chemical Co, Warren & Morris Sts, Jersey City 2, NJ.
Oronite Chem Co, 200 Bush St, San Francisco 20.
Rohm & Haas Co, Washington Sq, Philadelphia 5.
Scientific Oil Compounding Co Inc, 1637-55 South Kilburn Ave, Chicago 23.
R T Vanderbilt Co Inc, 230 Park Ave, New York 17.

STAFF REPORT

a guide to choosing and using . . .

MODERN FLUIDS for power and control

Hydraulic power-and-control fluids are available in abundance—one for almost every need—but how do you find the right one? Even the fluid manufacturers admit their catalogs cannot keep up wth the labs. One answer—given here—summarizes the basics underlying all such fluids, and supplies charts of typical properties.

FRANK YEAPLE, associate editor

Today there are power-and-control fluids engineered for almost any purpose. But the fluid types are so numerous, their properties so dependent on how the fluids are used, that manufacturers' catalogs can't give all the answers. This is why making a correct choice takes a team: design engineer; fluids expert; and the ultimate user. But only you—the design engineer—can finally decide what performance is essential to proper equipment operation, and what compromises are acceptable.

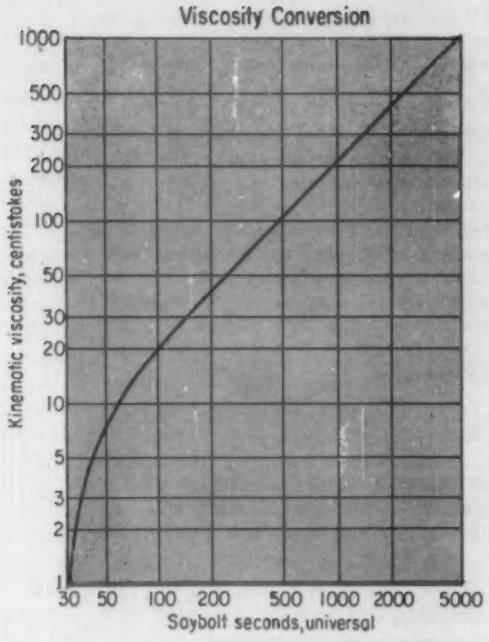
To help you, here is a guide summarizing the hydraulic basics, pointing out typical characteristics of general fluid types, but avoiding extensive detail. It helps you make a first guess before calling in the fluids expert for final help.

Matching Fluid to Job

Stating the selection problem in consistent language comes first. In simplest cases this is done by expressing needed system performance in terms of measurable fluid properties. For example, system flow and response are dependent on viscosity, density, vapor pressure, air solubility and bulk modulus. Additional properties not directly related to performance, but sometimes essential for safety, convenience and long life, are: fire resistance (if necessary), compatibility, fluid stability (temperature, pressure, radiation, etc.), lubricity, leakage, dirt-purging ability and cost.

But it is not always possible to express performance in simple numbers. In almost any system that has a pump or relief valve, localized flow is complex and it is difficult to predict peak pressure loadings, maximum temperatures and other conditions peculiar to a particular installation. The answer, although not covered in this

ACKNOWLEDGMENT: The material in this article is based on papers and talks given at two recent fluid-power conventions: National Conference of Industrial Hydraulics (NCIH); and National Fluid Power Association (NFPA). We thank R. L. Leslie and W. W. LeRoy of Vickers Inc for their graphs and detailed data on fluid properties, and Thomas Smith, Celanese Corp, for his concise evaluation of fire-resistant fluids, including the table of compatibility.



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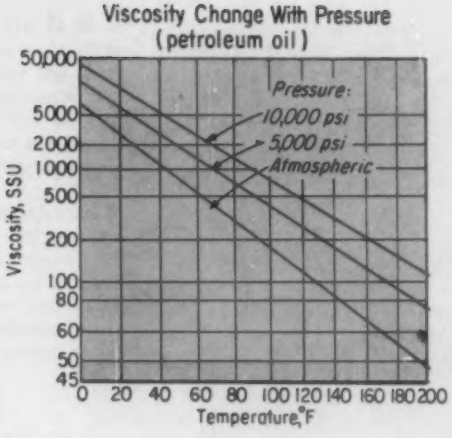

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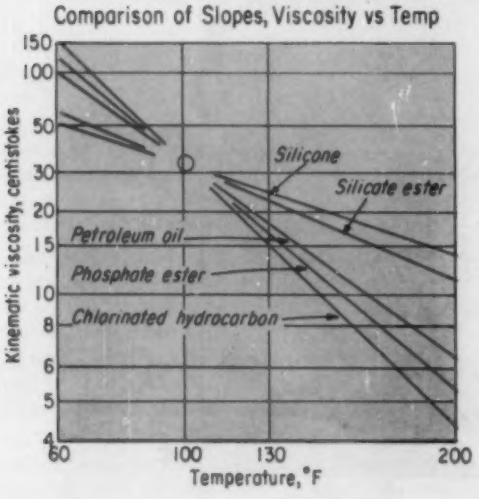


c

a VISCOSITY IN SSU is an accepted way to express kinematic viscosity of fluids for values of 100 SSU and above. Below that value, the relationship between true kinematic viscosity (centistokes) and SSU units is not linear on this scale.

b PRESSURE AFFECTS VISCOSITY of petroleum oils—particularly at elevated pressures (values are approximate). For most hydraulic fluids, viscosity will increase by 10 to 25% if pressure is increased from atmospheric to 1000 psi. Increase will be 30 to 70% from atmospheric to 3000 psi.

c TEMPERATURE AFFECTS VISCOSITY in widely different ways, even though the fluids selected for this example have identical viscosities at 100 F. None of the fluids are limited to the levels shown, however. Silicone fluids, for example, are available with viscosities ranging from less than 1 to over 1,000,000 centistokes.

article, is to test the fluid in a setup that duplicates or simulates expected field conditions.

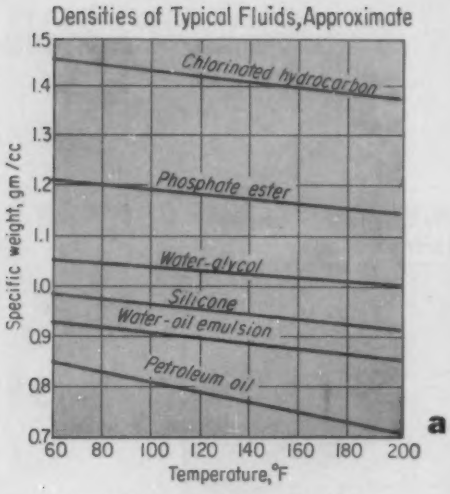
The fluid finally chosen will most likely be one or a special combination of some of these common types: petroleum (naphthenic, aromatic, paraffinic, inhibited, uninhibited); water; glycol (glycerin is a glycol); phosphate or silicate ester (an ester is formed by replacing the acid hydrogen of an acid with a hydrocarbon radical); and various hydrocarbons (chemical compounds containing only carbon and hydrogen). Silicone fluids are not common in ordinary industrial hydraulic systems, but find many applications in special circuits and devices, such as fluid springs, damping pistons, fluid couplings, and some power transmission units. These fluids have exceptional thermal stability. (see "*Liquid Spring*", *PE*—Aug 17 '59, p 54).

Many variations of the above fluids are possible—chlorinated hydrocarbons, for example. However, knowledge of chemistry is not essential, because the manufacturer will help select the exact type and grade to meet the need.

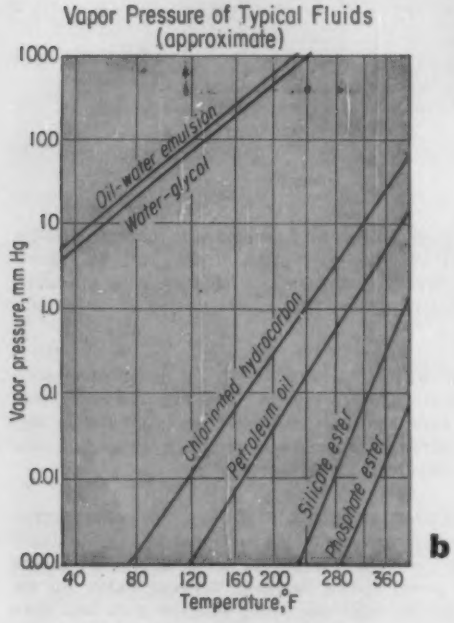
These Properties Affect Performance

Viscosity and density together determine pressure loss for a given flow (see "Pressure-drop Calculations," *PE*—June '54, p. 197). Viscosity is frequently expressed in SSU (Saybolt Universal Seconds) units, a measure of the time it takes for 60 cc of oil to flow through an orifice 0.176 cm dia and 1.225 cm long. In the accompanying graphs, SSU is related to kinematic viscosity, in centistokes. Values of viscosity as well as specific weight are given for several fluids. Kinematic viscosity in centistokes equals absolute viscosity, in centipoises, divided by mass density.

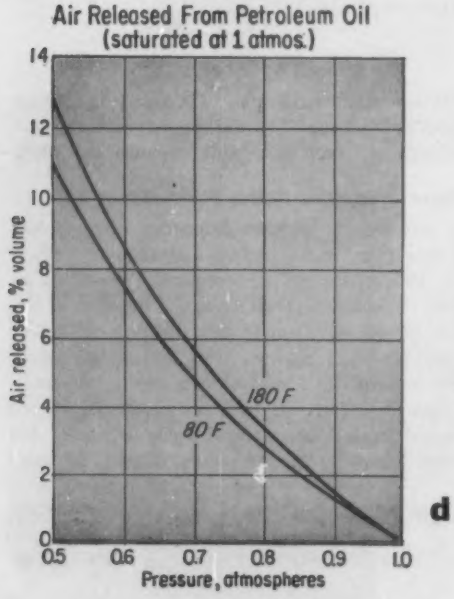
The slope as well as position of each viscosity-vs-tem-



a **DENSITIES VARY** not only with temperature (shown) but also with differences between fluids of the same type (not depicted—only one representative example of each fluid type is given).

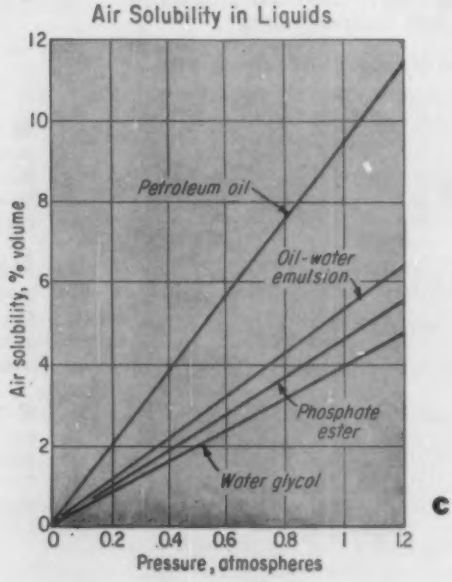


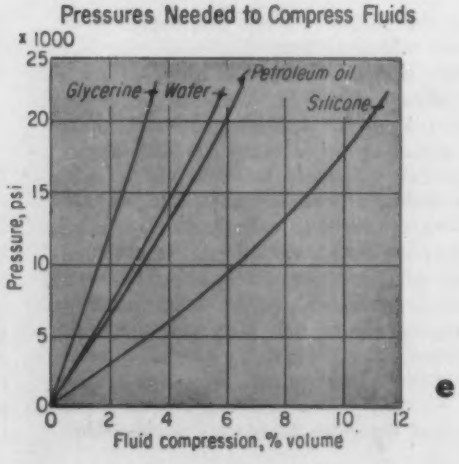
b **VAPOR PRESSURES** of water-based fluids are relatively high, magnifying the tendency to cause cavitation at pump inlets, particularly at high temperatures.



c & d **AIR SOLUBILITY** at any given pressure is the ratio of dissolved air volume (converted to 32 F and atmospheric pressure) and volume of fluid. Air released is actual volume of air that would come out of solution if petroleum oil, saturated with air (at atmospheric pressure, for two different temperatures) was then subjected to reduced pressures. All data are for equilibrium conditions.

e **AVERAGE BULK MODULUS** of each fluid during a given pressure increase is the pressure change in psi, divided by the percent compression expressed as a decimal. The average modulus for a typical petroleum oil from zero to 20,000 psi is 20,000/0.061—about 328,000 psi. For the silicone fluid shown (100 centistokes at 77 F) the average modulus is 20,000/0.11—about 182,000 psi.





perature curve is important—a flat slope indicates a large allowable temperature change before exceeding minimum and maximum values of viscosity. The term Viscosity Index (VI) was invented to compare those slopes. It is based on two standard oils that have been given arbitrary values of zero and 100 VI, respectively, not plotted here. The zero VI is for the steeper slope (a naphthenic-petroleum oil, sensitive to temperature changes); the 100 VI shows less sensitivity to temperature (a paraffinic-base oil). Today's fluids range in VI from negative to over 200.

Although viscosity is usually considered constant for a given temperature and pressure regardless of the flow, it is sometimes greatly influenced by the rate of shear. In fluids that have large-polymer molecules, rapid shear rates temporarily lower the viscosity—suggesting that the very-long-polymer molecules align in direction of flow. Permanent damage can also occur if there is high flow through small clearances. This tends to break down large molecules into smaller ones.

Density not only influences flow rate and pressure drop, but also affects the natural frequency of a system. This frequency is proportional to the square root of the moving mass.

Vapor pressure of the fluid, if too high, will cause gas pockets to form in areas of low pressure—such as in the inlet of a pump (see "Cavitation in Pumps," PE—Mar 2 '59, p 47). The graph shows that water-based fluids have fairly high vapor pressure . . . the system temperature must therefore be kept low to prevent vaporization and loss of water. Non-water-based hydraulic fluids, including silicones, have reasonably low vapor pressures.

Air solubility in many liquids is directly proportional to absolute pressure of the system. High solubility is undesirable because the air (or other gas) dissolved at reservoir conditions may come out of solution at a lower pressure (pump inlet, for example). Pump cavitation can result. If the reservoir is pressurized, then the problem is even greater because more air can be dissolved, coming out of solution later.

Bulk modulus—the reciprocal of compressibility—has units of psi. Bulk modulus is similar in concept to a mechanical spring rate, and measures the pressure change needed to cause a given percent volume change. The higher this modulus, the stiffer the system and the higher the resonant frequency. A fast-responding servosystem requires a fluid with a high bulk modulus.

Fire Resistance

Those fluids that meet stringent safety requirements usually sacrifice one or more performance qualities. Best known of the fire-resistant fluids are water, water-glycol, water-oil emulsions, phosphate esters, and chlorinated hydrocarbons. Each type falls into one of two broad categories: water-based or non-water-based.

Water-based types rely mainly on their water for fire resistance. Care must be taken to prevent loss of water from the mixture. Such loss in the glycol type increases the viscosity; but for the oil-emulsion type, it decreases the viscosity. In either case, change in viscosity (if noticed in time) can warn of a dangerous condition.

Water-based fluids are not usually recommended for high bearing loads found in ballbearings and axial-piston pumps, or for fluid pressures over 1000 psi. Also, rusting may occur if water-based fluids only partly fill a system—the water vapor increases oxidation rate on the exposed areas.

The non-water-based types such as phosphate esters and chlorinated hydrocarbons are not volatile, and can stand extremely high pressures and temperatures to 250 F. However, they are heavier than water-based fluids (and petroleum), and have the disadvantage of high viscosity at low temperatures—auxiliary heating is often required for outdoor startups.

Compatibility: Fluid and System

Hydraulic fluids must not give trouble with seals, filters, diaphragms and other materials. The accompanying compatibility table summarizes the conversion problems faced when petroleum oils are replaced with fire-resistant types. In no instance should a fire-resistant fluid be dumped into a system after merely draining the petroleum—although this has been "gotten away with" occasionally.

Before changing over to a fire-resistant fluid, be sure to completely clean the system. Residual amounts of petroleum and sludge can cause emulsion fluids to "break," and water-based materials to emulsify. Replace conventional 100-mesh strainers with 50- or 60-mesh units rated at 4 times' pump flow, instead of the normal 1½ times' pump flow. Limit pump-inlet vacuum to about 5 psi. Do not use fuller's earth or activated clay filters when additives are in the fluid . . . although they work well for chemically pure phosphate esters. Change all seals and packings where possible to materials that are compatible. At least change the dynamic seals, saving the static-seal change-over until a regular maintenance period. Don't grease O-rings with a noncompatible substance. Do not test the system with petroleum oil—use the intended fire-resistant fluid.

Ordinary joint compounds will be unsatisfactory. Stick to products recommended by the fluid manufacturer. One compound acceptable for many fire-resistant fluids, called "Loctite," is made by American Sealants Co. It can be applied in drops to the made-up joint; capillary attraction draws it into the thread, where it "sets" to become a vibrationproof seal. Another acceptable joint sealer is Teflon-type tape that can be wrapped around the male thread. Upon assembly, the threads cut the tape, forming individual gaskets for each thread. These tapes are available from Minnesota Mining and Manufacturing Co, Fluoro-Plastics Inc, and Friesland Plastics Co.

Elastomer-type materials suitable for various fluids are listed in the compatibility table:

Butyl is the best all-around elastomer for phosphate esters, but shows increased swell with chlorinated esters and other chlorinated fluids—care should be taken in close-tolerance dynamic applications. It is unsuitable where it may be exposed to petroleum oil in any quantity. Usable temperature range is −65 to 225 F.

Silicone material is recommended for chlorinated fluids. It has good temperature resistance, but is poorer than

Materials Compatible with Typical Fluids

	PETROLEUM OIL	WATER-BASE		NON-WATER-BASE		
		Oil-water Emulsion	Water-glycol Mixture	Chlorinated Fluids	Mixtures of Both	Phosphate Esters
Seals and Packings	Neoprene, Buna N	Neoprene, Buna N, (no cork)		Silicone, Viton, Vyram, Teflon, FBA Butyl (with caution)		Butyl, Viton, Vyram, Silicone, Teflon
Paints	Conventional		Consult Fluid Mfr.	Air-cured epoxy per mfr. recommendation		
Pipe-sealing Compound	Conventional		Special "dopes" such as "Loctite"			
Suction strainers	100-mesh wire, 1½ times pump capacity	40-mesh wire, 4 times pump capacity	50 mesh wire, 4 times pump capacity			
Filters	Cellulose fiber, 200–300 mesh wire, knife edge, or plate	Glass fiber, 200–300 mesh wire, knife edge or plate	Cellulose fiber, 200–300 mesh wire, knife edge, or plate	Cellulose fiber, 200–300 mesh wire, knife edge or plate type (fuller's earth or micronic type may be used on non-additive fluids.)		
Metal parts	Conventional		Avoid galv., zinc and cad. plating	Conventional		

butyl in tensile strength, tear and abrasion resistance—so needs care for dynamic sealing applications. Available temperatures range from −100 to 500 F.

Vyram is a trade name for an acrylic elastomer. It is suitable for all non-water fluids including petroleum, permitting fluid change without seal change. It is not suitable where exposed to water in any quantity. It can be used from −40 to 275 F.

Viton A is a fluorocarbon elastomer that seems to have considerable potential. It is suitable for all types of fire-resistant fluids as well as petroleum.

Teflon is well known for its chemical and thermal stability; however, its rigidity and tendency to cold-flow limit its application for dynamic seals.

Other Requirements

Fluid stability depends on the fluid's tolerance to temperature, pressure, atmospheric oxygen, water, radiation and catalysts. Petroleum oils have good oxidation resistance, except at high temperature—and oxidation is speeded up by the presence of certain metals. In long-chain organic compounds, high temperatures will degrade the large molecules into smaller ones, reducing viscosity. There are fluids already designed to be stable in almost any atmosphere, but usually a sacrifice must be made in other properties.

Lubricity of the phosphate esters is better than that for any other fire-resistant fluid, which helps justify their higher price. Water-glycol mixtures, unlike the fixed-composition esters, have varying proportions and ingredients, depending on the manufacturer. Therefore, the lubricity and other properties will vary. All types of fire-resistant fluids, however, will give satisfactory performance if applied correctly.

Maintenance and other costs cannot be predicted by rules, because high costs in one area—such as initial fluid cost—may reduce costs drastically in another. However, here are two important considerations. Leakage of fluid past seals is influenced by factors such as surface tension. Fluids which hold dirt particles in suspension are more troublesome than those which let the particles drop harmlessly to the bottom of the tank. And, of course, the compatibility of a fluid with the system and with other fluids it may contact is also a guide to costs.

FOR REPRINT of above article, just check P 28 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Detailed coverage has been given to fire-resistant fluids in these previous articles:

Synthetic Hydraulic Fluids, Dec '54, p 163, describes testing equipment such as the Shell-4-Ball, Almen-Wear, Timken-Lubricant, and various tests for fire-resistance, oxidation and so forth. Fluids tested were Pydraul, Skydrol, tricresyl phosphate and others.

Changing Over to Fire-safe Hydraulic Fluids, Nov '56, p 194, gives details of cleaning tanks, changing packings, controlling temperature, and testing system.

Designing for Fire-resistant Hydraulic Fluids, Aug '56, p 162, compares properties of water-based, synthetic and oil-emulsion fluids with those of petroleum.

Compatibility of fluids with seals and packings is discussed in **For Synthetic Hydraulic Fluids—Which Rubberlike Material,** Mid-Sep '59, p 535. It has a complete compatibility table, also introduces a solubility parameter that helps predict solubility and resistance to solubility, based on the energy of vaporization per cc of molecular volume.

For special fluids in extremely severe environments, watch for the article, **Unconventional Fluids,** coming soon.

8 simple methods measure . . . MOMENT OF INERTIA

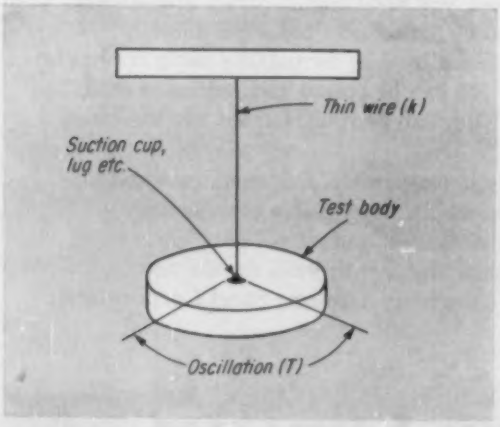
Oscillating and "falling weight" setups combine with simple formulas to give accurate answers for complex shapes.

BERNARD BRENNER, *staff engineer*
Ampex Corp, Redwood City, Calif

Moment of inertia is generally difficult to find when one or more of the following conditions exist: Body shape is irregular; material density is unknown; parts must be disassembled before precise dimensions can be found. The experimental methods shown here handle all such cases with sufficient accuracy for most engineering work. Only requirements: measurements of weight and time; and simple dimensions.

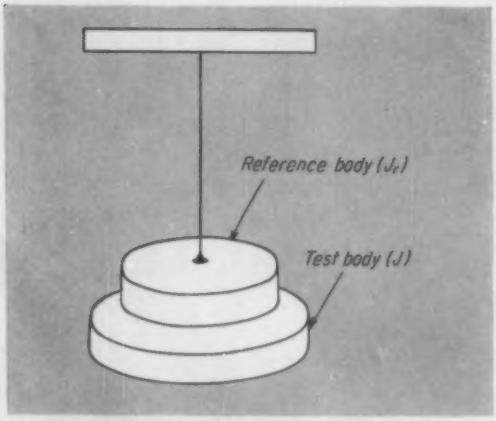
SYMBOLS

D = dia, in.
d = distance, in.
f = friction torque, oz-in.
g = gravity, in./sec²
J = inertia of test body about symmetry axis, oz-in.-sec²
J_r = reference inertia, oz-in.-sec²
k = torsional spring constant, oz-in./radians
L = length of pendulum, in.
R = radius, in.
T = period of oscillation (or time of weight fall), sec
W = weight of test body, oz
W_c = connecting-rod weight, oz
W_r = reference weight, oz



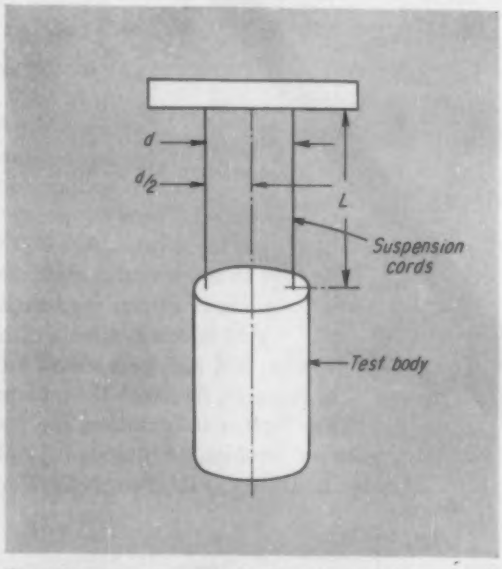
1—Torsional Pendulum (when k is known)

$$J = \frac{kT^2}{4\pi^2}$$



2—Torsional Pendulum (k is unknown)
T_1 is period with J_r only
T_2 is period with J_r and J together

$$J = J_r\left[\left(\frac{T_2}{T_1}\right)^2 - 1\right]$$



3—Bifilar Suspension (suspension cords must be highly flexible)

$$J = \frac{W d^2 T^2}{16\pi^2 L}$$

(Continued on page 63)

in this zone, stainless steels that remain ductile with high strength and stability

In the search for favorable strength-to-weight ratio, high temperature alloys have been developed with extreme strength up to 1090 F, but at the expense of ductility.

In AM 350 and AM 355, Allegheny Ludlum's precipitation hardening stainless steels, you have high hardness and stability from room temperature to 1000 F, plus almost twice the ductility!

These advantages are followed by easy formability using normal techniques. AM 350 and AM 355 can be brazed and welded as easily as the common stainless steels. They can be spun, formed and machined without special preparation.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Penna.**

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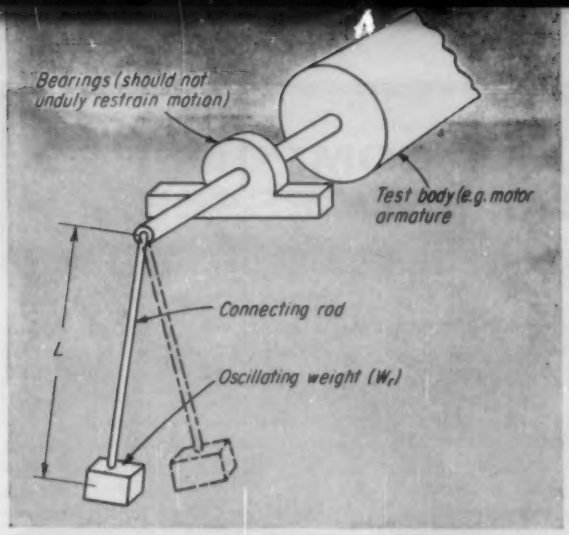
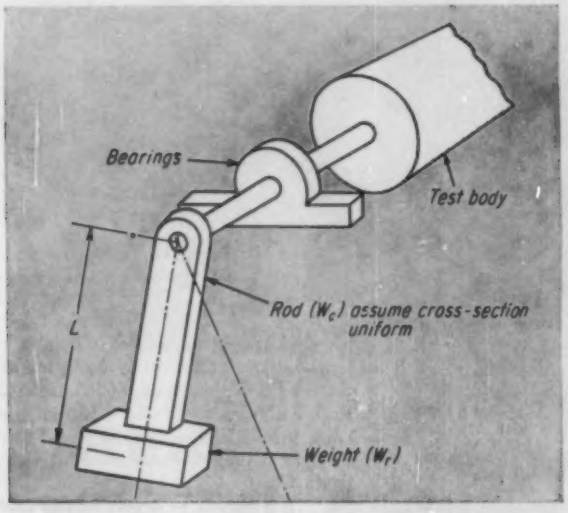
DESIGN FILE

MOMENT OF INERTIA (continued)



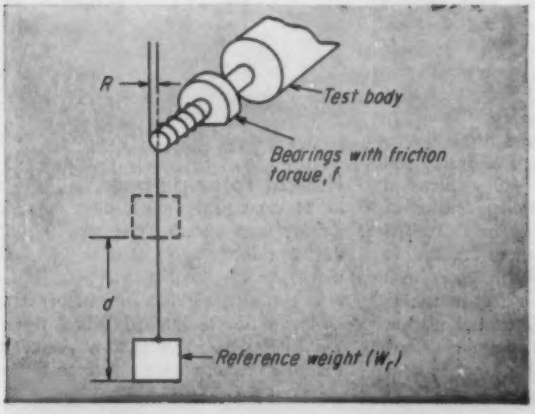
4—Pendulum (connecting-rod weight relatively light)

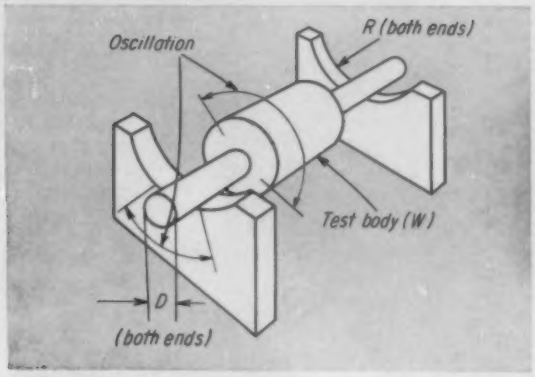
$$J = W_r L\left(\frac{T^2}{4\pi^2} - \frac{L}{g}\right)$$



5—Pendulum (connecting-rod weight appreciable)

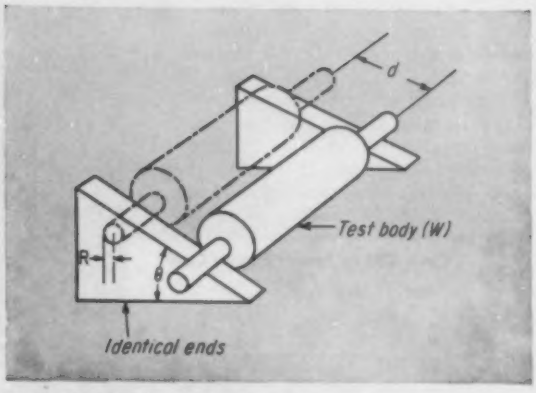
$$J = L\left[\frac{T^2}{4\pi^2}\left(W_r + \frac{W_c}{2}\right) - \frac{L}{g}\left(W_r + \frac{W_c}{3}\right)\right]$$





6—Rocker

$$J = \frac{WD^2T^2}{16\pi^2 R}$$



7—Inclined Plane

Body rolls d in. from rest (without slipping) in t seconds.

$$J = \frac{WR^2t^2}{2d}\sin\theta$$

8—Falling Weight

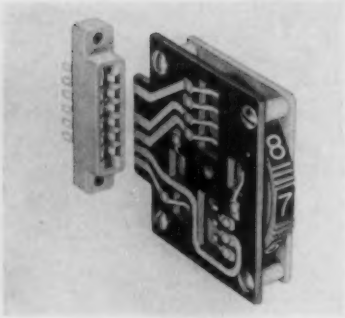
Weight W_r starts from rest and travels d in. in T sec. Frictionless:

$$J = W_r R^2\left(\frac{T^2}{2d} - \frac{1}{g}\right)$$

With shaft friction f:

$$J = W_r R^2\left(\frac{T^2}{2d} - \frac{1}{g}\right) - \frac{RT^2f}{2d}$$

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Binary thumbwheel switch . . . is modular 10-position unit. Requires ½ in. panel space. Only one number at a time is exposed through bezel window. Available with wafers replaceable in 10 sec or with fixed wafers. Removable type switch plugs into fixed printed circuit receptacles; fixed wafer switch has soldering terminals. Modular construction permits horizontal or vertical stacking. Switch is manually operated by ¼ in. thumbwheel available in black or colors for each module. Aluminum mounting frames are offered in lengths to accommodate up to 16 switches. **Chicago Dynamic Industires Inc, Precision Products Div, 1725 Diversey Blvd, Chicago 14.**

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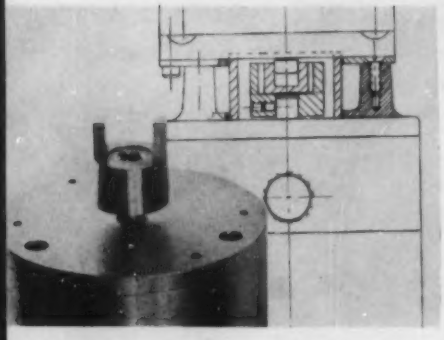

Rotary valve actuator . . . is said to have high accuracy and high response for remote or automatic control of hydraulic valves and process control. Low-cost electric actuator, 4½ in dia x 5 in. long, slips on valve stem. Develops torque of 125 in.-lb and provides full-scale control in 1 sec minimum; remote-control accuracy is one part in 1000. Has fully enclosed and lubricated gear trains, weatherproof construction, choice of power supplies and motor with ample heat sink to permit continuous operation at locked rotor current. May be pushbutton-controlled from 115 v, 60 cps supply or furnished with dial-type remote positioner. Automatic control is usually provided by transistor-equipped, printed-circuit amplifier, which drives motor-control phase from last-stage power transistors. Amplifier, when used as remote positioner or in automatic control, is furnished in 8¾ x 5¾ x 5¾ in. steel cabinet. Suitable for panel mounting or mounting directly to frame of controlled machine. Acceptable control signals include 3 to 15 psi air and 0.5 to 5 milliamp. Price varies from $89.50 to $366, depending upon power output and response characteristics. Delivery, 4 to 8 wk. **Jordan Controls Inc, 3235 W Hampton Ave, Milwaukee 9.**

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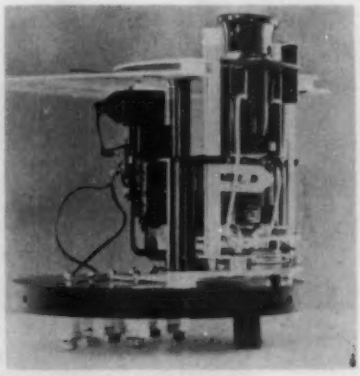

Measuring controller . . . combines a photoelectric switching assembly and an electrical measuring instrument in compact panel unit without physical interaction between the two functions. Measuring instrument is available in moving coil and single electrodynamic movements. Moving coil ranges are from 40 microamp to 60 amp and 10 microv to 600 v. Single electrodynamic movements have normal current of 5 amp and voltage of 110, 220 or 440 v. Standard accuracy is 1.5%. Controller consists of blue minimum and red maximum control marker, with photo resistance attached to each marker. Beam of light moves with measuring pointer and when measuring pointer is lined up with control marker, beam enters photo resistance window and activates relay outside instrument. Switch accuracy is said to be better than 1% of scale and value. Min distance between control markers is 1.5% of full scale value. Available with one control marker, also. Measuring pointer is free to indicate values over full scale, irrespective of position of control markers. Prices vary depending on type of instrument and type of remote switching assembly. At present, delivery is about 60 to 90 days. **National Electronics, PO Box 1237, Sheridan, Wyo.**

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Miniature ¼-turn fastener . . . has receptacle that measures 0.812 x 0.375 in. over-all x 0.012 in. thick. Retainer and stud are correspondingly proportioned. Six stud lengths accommodate total material thickness of 0.040 to 0.159 in. All three parts are made of cadmium-plated steel. Fasteners, which offer 0.020 in. grip range in each stud length, require ¼-turn to open, ¼-turn to close. **Southco Div, South Chester Corp, Lester, Penna.**

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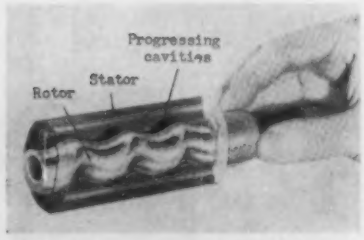
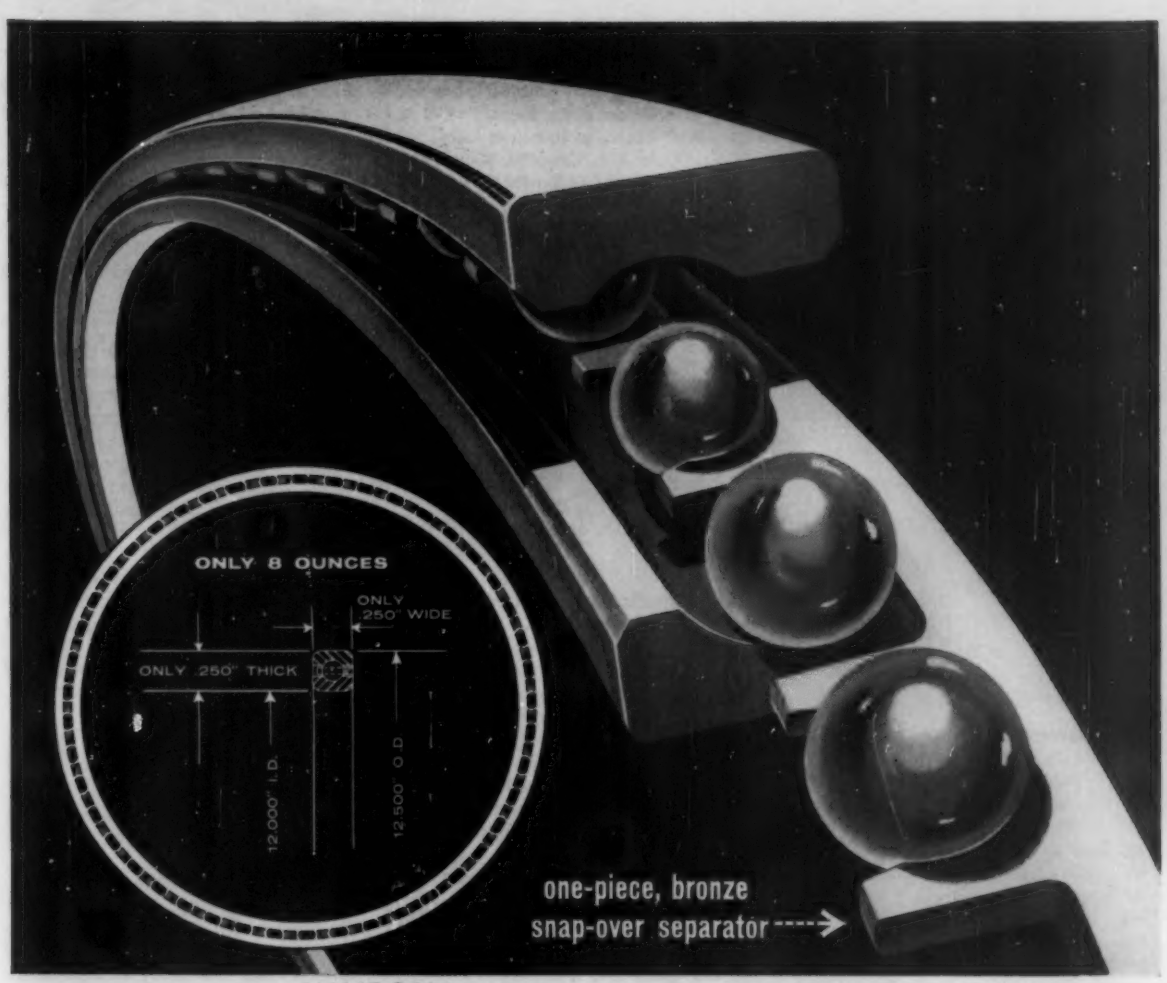


Helical rotor pumps . . . in 24 catalogued models offer deliveries ranging from metering flow to 1200 gph; discharge heads range to 300 psi. Only moving part is stainless steel helical screw rotor that turns within a fixed rubber stator having a double internal helical thread. Resulting pumping action is similar to that of a precision screw conveyor; cavities

(Continued on page 66)



News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

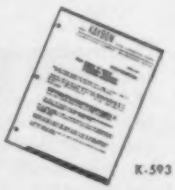
Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.



K-593

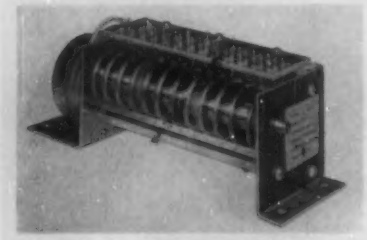
THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings • 4-Point Contact Ball Bearings

formed between rotor and stator move toward discharge end of pump, carrying material being handled. Said to provide positive displacement, low internal turbulence and continuous, uniform flow suitable for metering. Also enables pumps to handle broad range of materials, from water-like liquids to heavy, abrasive slurries and substances containing relatively large particles in suspension. Available with or without direct-connected motors. Designed for production in quantities of 100 min. **Moyno Pump Div, Robbins & Myers Inc, Springfield, Ohio.**

Circle 304 on Reader Service Card



Programming timer . . .

measures 2¼ x 2¼ x 7 in. but contains 12 SPDT independently adjustable and removable load switches. Motor operates on 115 v, 60 cps power. Time cycle is 90 sec. Said to withstand vibration of 0.060 in. double amplitude displacement from 5 to 55 cps and shock of 30 g for 11 millisec. Extra large cams, 1½ in. OD, allow time settings with accuracy of 1% or better. **Eagle Signal Co, Moline, Ill.**

Circle 305 on Reader Service Card

Nylon-plastic conveyor belting

is loomed of heavy nylon yarn as a complete belt and the space between yarns is filled with polyvinyl chloride. Said to produce a lightweight, high-strength, fire-resistant material that out-performs conventional rubber conveyor belting. Reported to be noncorrosive, non-tearing, abrasive resistant. Available from stock in 30 and 36 in. widths, list priced at about $7 and $8 per ft, respectively. **Russell Mfg Co, Middletown, Conn.**

Circle 306 on Reader Service Card

Thermocouple probe . . .

measures liquid and gas temperatures in 1800 F range at pressures in excess of 2000 psi. Available in various standard lengths. Models include those with stainless steel sheaths and either covered or exposed probes for use with hot gases and ceramic sheaths for use with liquid metals and acids. Suitable for connection to low-temperature Teflon or high-temperature MgO cable. Constructed of chromel-alumel or chromel-constantan with ⅜-18NF mounting thread and ⅞ in. hex body. **Technical Industries Corp, 389 N Fair Oaks Ave, Pasadena, Calif.**

Circle 307 on Reader Service Card

Miniature coaxial switch . . .

for 50 ohm cable can be directly inserted into miniature circuits without adapters. Mating connectors are available for application at, above or below 400 mc. VSWR is less than 1.2 to 2 kmc and insertion loss is 0.5 db at 2 kmc. Voltage rating is at 1500 v max, 60 cps, and cross-talk is said to be better than 60 db to 2 kmc. Operative life is reported to be 50,000 cycles min. Weight 1¼ oz. **Microdot Inc, 220 Pasadena Ave, South Pasadena, Calif.**

Circle 308 on Reader Service Card

Elastomeric-base adhesive . . .

is for spray application, high-strength bonding of porous and non-porous materials. Said to offer wood-to-steel bonds with shear strength in range of 400 psi. Applied automatically or by hand spraying both bonding surfaces to achieve dry film thickness of 2 to 3 mil on each surface. Films are dried at 200 F and immediately bonded under 100 psi. **Minnesota Mining & Mfg. Co, Adhesives and Coatings Div, 900 Bush Ave, St Paul 6.**

Circle 309 on Reader Service Card

Portable plasma flame spray gun . . .

utilizes electric arc and inert gases to produce flame temperature to 30,000 F. Despite normal melting temperatures of 10,000 to 15,000 F, sprayed work is reported to stay cool. Nitrogen with 5 to 10% hydrogen is passed through electric arc that is confined in bore of nozzle. Gas is dissociated and ionized to form plasma within nozzle. Both nozzle and gun body are water cooled. In general, most inorganic materials that can be melted without decomposition can be applied. Coating densities run up to 98% of theoretical and said to be controlled easily. High-fluidity of particles and high-impingement velocity bond particles together to produce high-density coatings. Absence of air eliminates oxidation. Type MB unit is $2,000, FOB Chicago. **Metallizing Engineering Co Inc, 1101 Prospect Ave, Westbury, NY.**

Circle 310 on Reader Service Card

Holes of less dia than thickness

can be punched by rapid-phase tooling for metal stampings. Rapid-phase tooling is used for production in quantities of 10 to 10,000 parts. Costs are said to average 20% of conventional tooling costs. Max blank sizes are 14 x 20 in., ⅛ in. thick and up to 400 ton pressure. All metals are available, including laminates and exotic metals. In addition, phenolics and other non-metals are available from stock. **Federal Tool & Mfg Co, Dept HL, 3716 Alabama Ave, Minneapolis 16.**

Circle 311 on Reader Service Card

Low-cost silicon transistor . . .

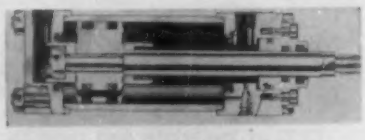
has been developed for application, particularly in the field of industrial controls, where full use of silicon transistors has not been possible because of the price ratio between silicon and germanium devices. Said to have low saturation voltage and good current gain at collector current levels to 50 milliamp. Offers 1 microamp collector cutoff current, 250 milliw power dissipation, and close parameter control through —285 to 320 F. **Raytheon Semiconductor Div, Raytheon Co, 215 1st Ave, Needham Heights, Mass.**

Circle 312 on Reader Service Card

19 to 55% greater load . . .

capacities than obtainable with equivalent size Conrad type bearings are said to be possible with these split-ring radial ball bearings. Life expectancy is reported to be up to 298% greater. Bearings are more rigid, with average of 20% less radial deflection and have two to six more balls. Offered in ABEC-3 and ABEC-5 precision grades, bearings are made in extremely light, extra light, light and medium series, in metric sizes to 85 mm OD. Four ranges of internal clearance are available. **Split Ballbearing, Div of MPB Inc, Lebanon, NH.**

Circle 313 on Reader Service Card

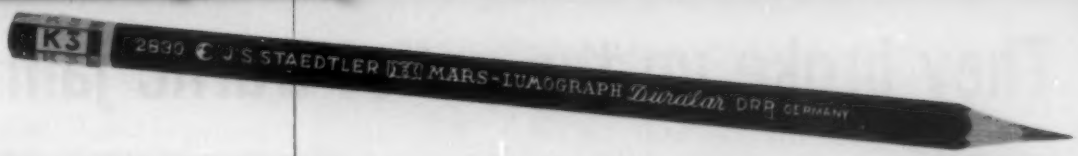


Low-pressure cylinders . . .

for 250 psi air and 400 to 1000 psi hydraulic service are offered in 1½ through 8 in. bores. Wide variety of mountings, rod diameters and rod ends. Choice of packings meets high or low temperature requirements. For added strength, mountings are welded to one-piece steel heads. To prevent leakage, O-ring seal, located

(Continued on page 69)

CIRCLE 67 ON READER SERVICE CARD→



WON'T SMEAR ON MYLAR®!

Duralar

Still the only pencil

that **can't smear** on Mylar, that **keeps a point** on Mylar, that **erases** on Mylar. Duralar drawings on Mylar **reproduce** perfectly, **microfilm** without loss and can even be **cleaned** with soap and water.

For free samples

of Duralar pencil and leads and leading brands of matte-surface Mylar drafting film, just fill out the coupon and attach to your business letterhead. See for yourself how the sensational new Mars Duralar solves your drafting problems. And Duralar is available (pencils, leads and lead holders) in five special new degrees of hardness (K1 to K5). Sold at leading engineering and drawing material suppliers.

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Gentlemen: Please send me FREE

- ☐ Samples of revolutionary DURALAR pencil and leads
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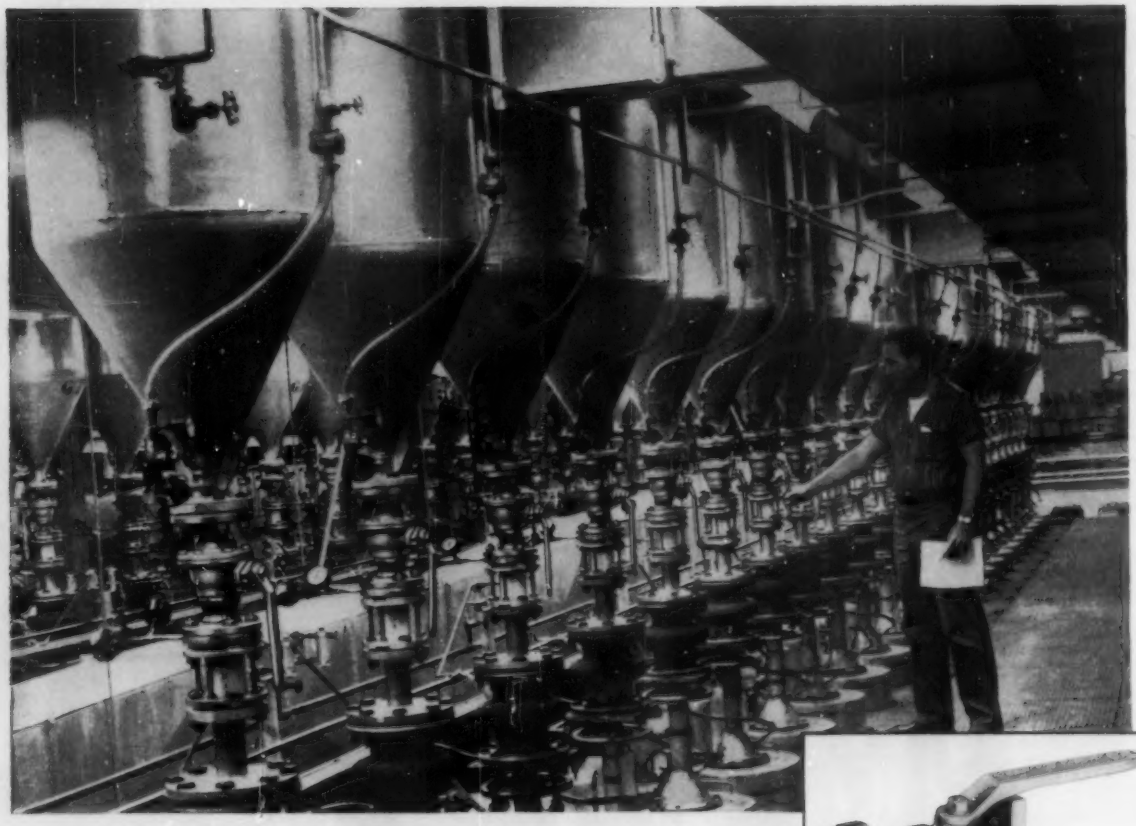
NAME _____ TITLE _____

FIRM _____

STREET _____

CITY _____ ZONE ___ STATE _____

They broke up the pellet traffic jam...



with Rockwood Ball Valves

A costly and recurrent problem in a large southern synthetic fibre mill was the jamming of polymer pellets as they came from supply hoppers. Source of the trouble was the tapered-throat design of the valves. Even with valves fully open, pellets piled up. In addition, this packing-in action caused severe abrasion on the valves. The problem was solved by replacement with Rockwood Ball Valves. Their *straight-through-opening* feature now permits pellet to flow smoothly . . . and the wear problem has been automatically eliminated because Rockwood valves offer no more resistance to flow than the pipeline itself.

What's more, after hundreds of openings and closings Rockwood Ball Valves still provide *positive leak-proof* shut-off means. A retainer spring, which *automatically compensates for pressure variations* keeps the seat snug against the ball and holds tight even under vacuum.

Thousands of Rockwood Ball Valves are giving efficient service and cutting costs throughout industry — in oil refineries, textile mills, paper, chemical and rubber plants.

There are types and sizes to meet every requirement in *your* plant. Write today for the illustrated folder on Rockwood Ball Valves. Tested and listed by Underwriters' Laboratories, Inc. Rockwood Sprinkler Company, A Division of The Gamewell Company, 827 Harlow Street, Worcester 5, Mass. Distributors in principal industrial areas.

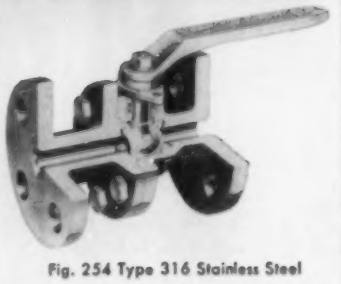


Fig. 254 Type 316 Stainless Steel

Rockwood Ball Valves are available in pipe sizes ⅜" through 16" in screwed ends 150 lb. and 300 lb. flanges. All internal parts are of Type 316 stainless steel with spring-compensated TEFLON* seats. Recommended for 600 p.s.i. working pressure and suitable for temperatures ranging from—100° F. to 400° F. All sizes are available with two retainer springs and two Teflon seats.

*DuPont Reg. T. M.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

on OD of tube, is confined by head and tube so that it will not extrude at high temperatures. Check-seal cushions are said to minimize destructive effects of heavy or high-speed loads. Hanna Engineering Works, 1765 Elston Ave, Chicago 22.

Circle 314 on Reader Service Card

Nylon pressure tubing . . .

is available off the shelf in continuous lengths from 0.010 x 0.060 in. min to 0.280 x 0.500 in. max. Material is shipped on reels. Garlock Packing Co, Div United States Gasket Co, 440 Main St, Palmyra, NY.

Circle 315 on Reader Service Card

High-pressure piston pump . . .

offers working pressure and delivery to 4.2 gpm at 3000 psi and 90% efficiency. Has four bearings located on 4½ in. of 6-in. shaft. Positive displacement pump is said to have long life and low noise level. Overall size is 3¾ in. dia x 8½ in. long; weight is 12¼ lb. Mark Hydraulic Co, 3707 N 24th St, Omaha, Nebr.

Circle 316 on Reader Service Card

Motor-load indicator . . .

for single- or three-phase, 50- or 60-cps induction motors is designed for use with 5-amp current transformer. Measures useful or working component of load current. Meter is calibrated for 190 to 280 v or 350 to 550 v. Flush-mounted case may have either 4 in. sq or 4½ in. round mounting flange. Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.

Circle 317 on Reader Service Card

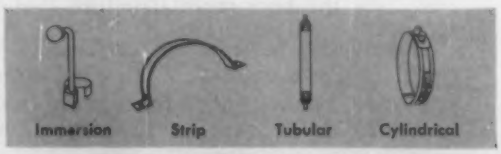
2-circuit pushbutton switch . . .

is designed especially for punch presses and similar types of hand-operated power equipment. Oil-proof switch has two-circuit double-break (one set breaks before other set makes) contact arrangement. Die-cast cover has collar around phenolic button. Fits into conventional FS and FD electrical boxes mounted with four No.

(continued on page 72)

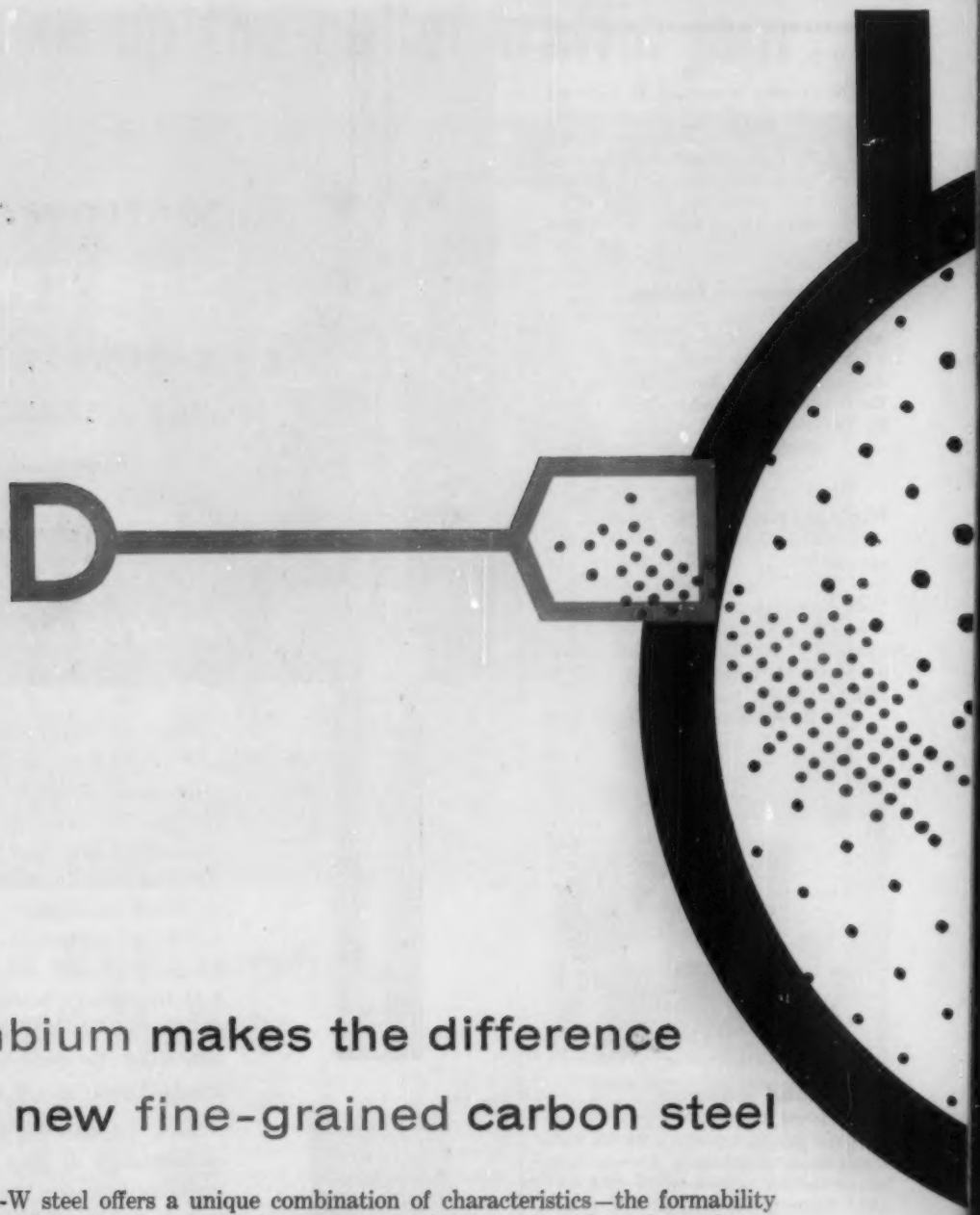
Watlow's FIREROD combines in one unit the best of all those factors most often sought in an electric cartridge unit: it's the *HOTTEST* heater going (gives you 5 times more heat than any standard unit, yet offers an amazing *heat range* up to 1500°F and higher) . . . the *LONGEST LASTING* cartridge operating at *any* temperature (will out-live, out-perform 5 to 10 ordinary heating units) . . . and the most *DESIGN-WISE* cartridge available today (the *same* heat you'd get in a standard unit, in 1/5 the space).

So . . . whether you're looking for high concentration of heat or longer-lasting cartridge heaters – you'll want to learn more about the FIREROD. WRITE for FIREROD BULLETIN #367.



WATLOW
ELECTRIC MANUFACTURING CO.
1392 Ferguson Avenue
St. Louis 14, Mo.

CIRCLE 69 ON READER SERVICE CARD



Columbium makes the difference in this new fine-grained carbon steel

The new GLX-W steel offers a unique combination of characteristics—the formability and weldability of mild carbon steel *plus* greater tensile strength and notch toughness.

The addition of small amounts of columbium gives GLX-W the finer grain structure that makes this possible.

Where design permits, the use of GLX-W can result in weight savings up to 35%, compared with mild carbon steel. With yield strengths ranging from 45,000 to 60,000 psi, GLX-W steels are recommended for a broad range of applications. For technical information, write to our Product Development Division, Department A.

GREAT LAKES STEEL
Detroit 29, Michigan

Great Lakes Steel is a Division of **NATIONAL STEEL CORPORATION**

GLX-W

CIRCLE 71 ON READER SERVICE CARD

6-32 screws. Electrically rated for pilot circuit control up to 600 v ac or dc. Delivery from stock. $9 each, list. **Vemaline Products Co, PO Box 222, Hawthorne, NJ.**

Circle 318 on Reader Service Card

60-cps motor generator . . .

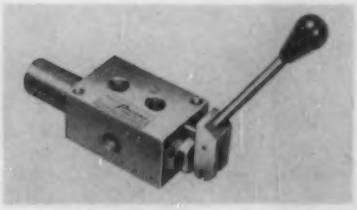
is utilized as damping tachometer, rate generator, or as integrator performing mathematical computation in industrial servo loops serving as automatic controls. Operates on 115 v. Rotor moment of inertia is 18 gm cm²; no-load speed is 3000 rpm. Stall torque is 5 in.-oz. Weighs 28 oz. **Kearfott Co Inc, Little Falls, NJ.**

Circle 319 on Reader Service Card

Metallized polyester film . . .

and vinyl composition has pressure-sensitive backing for use as product decoration, trim or identification. Available embossed, printed or plain, in copper, chrome, gold or brass. Samples available. **Allen Hollander Co Inc, 385 Gerard Ave, New York 51.**

Circle 320 on Reader Service Card



Miniature 4-way control valve

with sliding-spool construction is for use in small hydraulic circuits, under 3 gpm. Offers low pressure drop of about 13 psi at rated capacity of 3 gpm. Internal leakage is said to be less than 10 cu in. per min. at 2000 psi with 150 ssu oil. Balanced spool is hard-coated aluminum. Valve, which measures 2 x 1½ x 5 in. plus handle, is available with standard ⅛ and ¼ in. dry-seal pipe threads. Weighs 1 lb 2 oz. **Sarasota Precision Products Inc, 5757 McIntosh Rd, Route 1, Sarasota, Fla.**

Circle 321 on Reader Service Card

4-way solenoid valve . . .

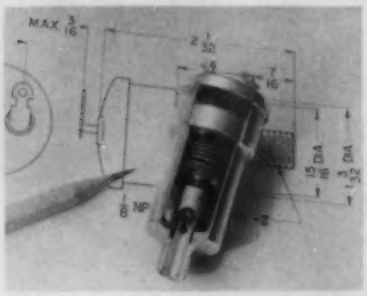
is for pneumatic or hydraulic fluid power applications in 40 to 300 psi range. Full $\frac{7}{16}$ in. dia flow area. Valve bridges gap between small-flow, direct-acting solenoids and standard ⅛ to ¼ in. full-ported valves. Available in over 100 different variations in side-ported and manifold models, with single or double solenoid actuation. Single solenoid valve is 5¼ x $1\frac{7}{8}$ in. dia; double solenoid measures 8 x $1\frac{7}{8}$ in. dia; average weight is less than 2 lb. **Versa Products Co Inc, 150 Coolidge Ave, Englewood, NJ.**

Circle 322 on Reader Service Card

Right-angle bracket nut . . .

is self-locking unit for use in attaching wire bundles and plumbing lines. Replaces variety of attachment methods. Made of cadmium-plated carbon steel, heat-treated for performance to 550 g. Mounting holes, 0.130 in. dia, permit use of ⅛ in. aluminum alloy rivets. Presently available in 10-32 thread size in 0.450, 0.650 and 0.850 in. bracket lengths. **Elastic Stop Nut Corp of America, 2330 Vauxhall Rd, Union, NJ.**

Circle 323 on Reader Service Card



Non linear gas-density switch

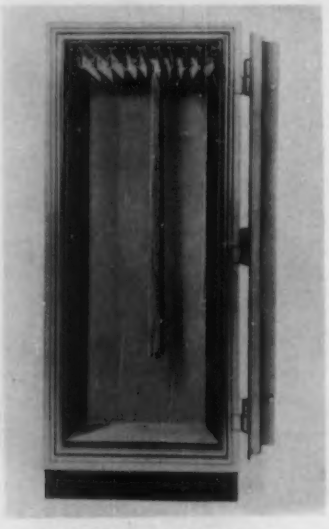
monitors densities in presence of vapors. Signal when critical gas plus liquid-vapor densities are approached. Pressure differential between actuate and deactuate is 1 to 3½ psi. Weighs 2 oz, measures $2\frac{3}{32}$ x $1\frac{5}{32}$ in. dia. Available SPST or SPDT, rated 28 v, dc, 110 v ac, 5 amp non-inductive. **Newark Controls Co, 15 Ward St, Bloomfield, NJ.**

Circle 324 on Reader Service Card

Dynamic pressure calibrator...

measures transient response of pressure pickups and connecting lines. It applies step pressure to the pickup, which responds according to mechanical and acoustical characteristics. Cellophane or acetate film is placed over pressure pickup inlet and pressurized air is applied to diaphragm thus produced. Solenoid-actuated knife bursts diaphragm, releasing pressure very rapidly. Pressure step from known position value to atmospheric pressure results. Pressure step ranges, 5 to 100 psi; rise time of pressure step, 0.1 millisec (varies with connected volume). **Wiancko Engineering Co, 255 N Halstead, Pasadena, Calif.**

Circle 325 on Reader Service Card



Vertical blueprint safe . . .

holds up to 1000 plans in fireproof, burglarproof compartment. Prints are retained on 30-in. long, T-topped removable steel gliders. Evenly-space thumbnuts on plan holders tension-hold 100 prints, to 30 in. wide and 48 in. long. Weighs about 1000 lb. Safe, 58¼ x 23¼ x 36½ in. deep, is made by Ever-Safe Co Inc, Lafayette, Ind. Vertical filing components are by Momar. **Momar Industries, 4176 W Montrose Ave, Chicago 41.**

Circle 326 on Reader Service Card

Aeroquip PUSH-PULL Hydraulic Couplings Connect and Disconnect Fluid-Carrying Lines

QUICKLY and EASILY

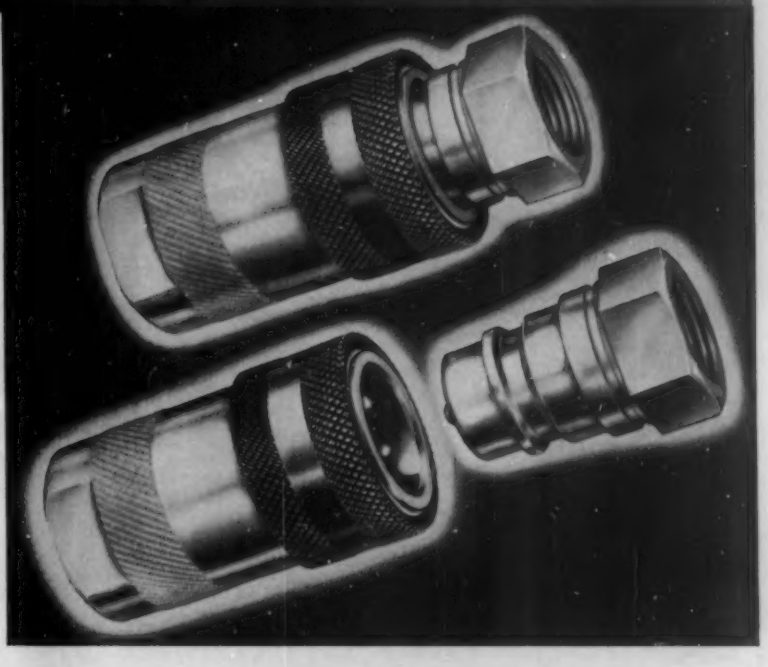
AVAILABLE IN TWO THREAD TYPES FOR INDUSTRIAL APPLICATIONS

5600 Series

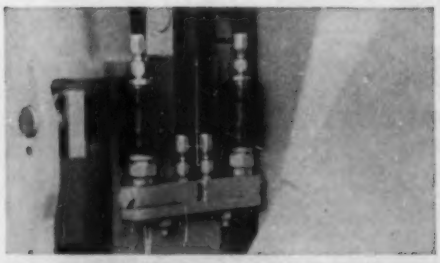
For N.P.T.F. pipe thread connection in ¼" ⅜", ½", ¾" and 1" sizes.

5606 Series

For all S.A.E. straight thread boss (O-ring seal) connections up through 1" tube sizes.



- **Quick Connection and Disconnection**
- **Positive Sealing—Connected or Disconnected**
- **Full Flow With Negligible Pressure Drop**
- **For Working Pressures Up to 3000 psi.**
- **Simple, Rugged Components**



Aeroquip PUSH-PULL Couplings on hydraulic lift truck.

The new Aeroquip PUSH-PULL Coupling is designed for quick, easy connection of hydraulic lines. It features a simplified poppet valve seal that gives long, leakproof service life. The coupling is constructed to protect against entry of dirt into the hydraulic system. Where connect-under-pressure feature is desirable, the 5650 Series PUSH-PULL Coupling is available.

Complete design information on the Aeroquip PUSH-PULL Coupling series is available. Fill in and mail the coupon below for your copy.

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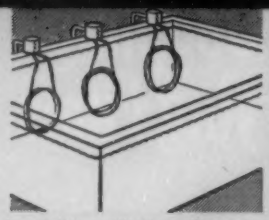
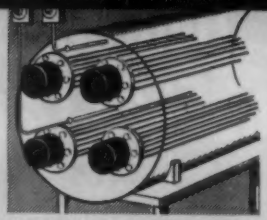
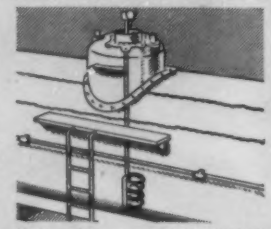
Call your CHROMALOX Man for heating answers



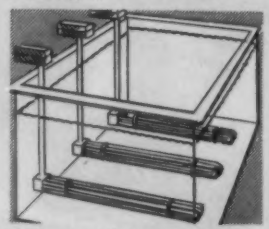
For plating applications, Chromalox CT Immersion Heaters are sheathed in lead, copper, stainless steel.



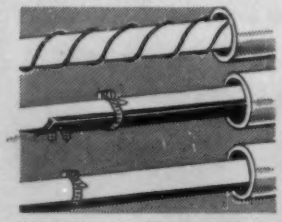
Water heating with TM flange-type Immersion Heaters mounted at one end of a tank.



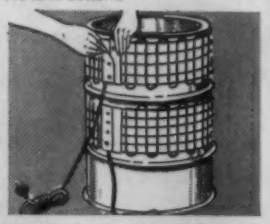
Heating viscous materials with BLCK Immersion Heaters before pumping from a railroad tank car.



Heating liquid held at constant level. TL Heaters generate heat parallel to the tank bottom.



Pipe heating with Chromalox Thermwire (300°F), Strip Heater (750°F) and Tubular Heater (1100°F).



Heat for 5- and 55-gallon drums. Just snap on and plug in. Protective coating resists abrasion, chemicals.

LIQUIDS? Only CHROMALOX heats so many things . . . so many ways

There's one best way to do any job. And you get the best results only by using that one best method.

Regardless of what your heating problems may be . . . your best chance of finding the best answer is to call your Chromalox Man.

- He represents more than 15,000 different types, sizes and ratings of electric heaters and heating elements . . . the world's largest line.
- He orders from the world's largest stock.
- And he is a *heating expert* . . . he understands your problem and can help you find the answer.

No matter what your heating problem is . . . solids, liquids or gases . . . call your Chromalox Man for the efficient, *electrical* answer. (*His phone number is listed at the right.*) Or, check the boxes below, write your name, title, and address at the bottom of this page and mail it to us. Edwin L. Wiegand Company, 7500 Thomas Boulevard, Pittsburgh 8, Pa.

☐ Send me Catalog 60 (General Industrial heating applications).

☐ Have a Chromalox Representative contact me.

☐ Send me specific information on the heating problems I have outlined on the sheet attached.

☐ Do not have a Chromalox Representative contact me.

91649

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OMAHA, NEB. Atlantic 7600
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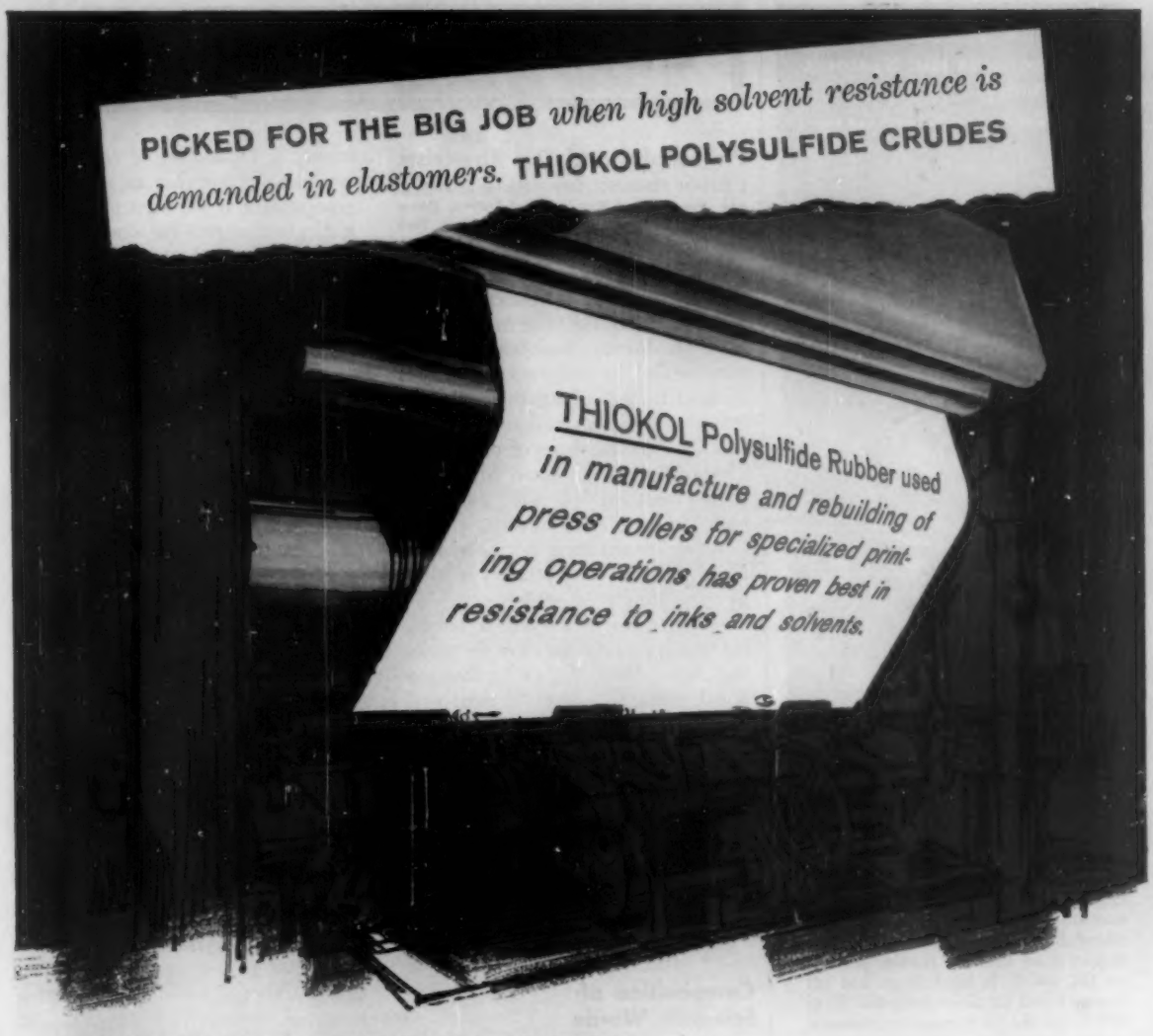
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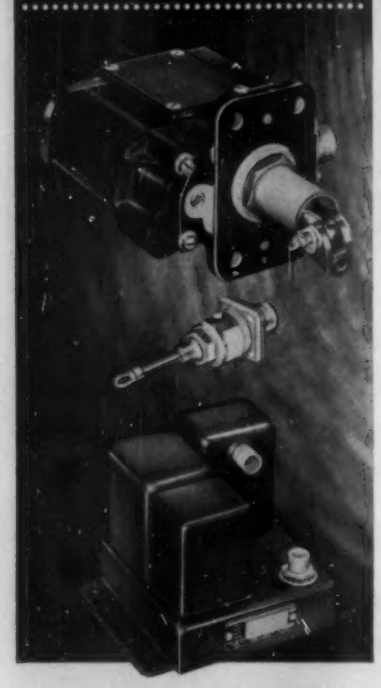

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One of a wide variety of temperature control systems developed and produced by AiResearch, this magamp temperature control system is used on the DC-8. It modulates hot jet engine bleed air down from 660°F. to 450°F. for the low pressure pneumatic system serving the air conditioning, refrigeration and ice protection subsystems.

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DESIGN LITERATURE

Philosophy and The Physicists

L SUSAN STEBBING, late Professor of Philosophy, University of Bristol, Great Britain. Dover Publications Inc, 180 Varick St, New York 14. 5½ x 8 in, 295 pp. $1.65.

Paraphrasing the first sentences of Mrs Stebbing's introduction, this book might be said to be in defense of all of us who have been overawed and even misled by scientists when they descend from the heights of scientific infallibility to write for us their supposedly objective views of philosophy. The author has in mind Sir Arthur Eddington, the physicist, and Sir James Jeans, the astronomer.

While emphasizing her admiration for these two men because of their great scientific contributions, Mrs Stebbing provides us with a refreshing evaluation of the way in which they write of their disdain for the emotional, inexact language of most philosophers. The evaluation makes it plain that Eddington and Jeans, like many of their scientific and engineering colleagues, also are given to inexact, emotional phrasing—particularly when expressing their own philosophical convictions. This is an unabridged paperback version of the original English edition. —JK

Composition of Scientific Words

D B BROWN. Available through Editorial and Publications Div, Smithsonian Institution, Washington 25, DC. 6 x 9, 881 pp. $8.

What's an infinitron? Well, Dr Brown says in his good-humored way, an infinitron is a cleaver with which you neatly split infinitives.

And what's a logotechnician? It's what Dr Brown says he is. It's a word he composed to describe a composer of words.

Philologists in general and etymologists in particular have long been leery of the glisteny-new and often inelegant neologisms of science—ranging from Freud's deceptively simple *id* to blockbusters like the recent *magnetohydrodynamics*. That's why we welcome this learned book by a former geologist of the US Geological Survey.

True, it does have a drawback for engineering readers: Its lexicon spends most time with the biological sciences. Nevertheless, if you are pioneering in science or technology, if you want to coin a word for your new theory or new product, if you want to do it with meticulous respect for word-roots you dig up in Greek, Latin—or maybe Sanskrit—this book tells how.

Also, it's good-natured instead of angry about our mistreatment of words; it includes a superb history of how the English language grew; you can discover a lot of synonyms by browsing through this volume, which in the main is a sort of hybrid—dictionary crossed with thesaurus.

So let's play word-games with Dr Brown, wordsmith, as guide. You've designed a new, circular-shaped instrument. What to christen it? Why not *trochotron*—Greek *trocho* (circular) plus Greek *tron* (instrument)? And if you want some Latin flavor too, then substitute *brum* for *tron* and you call the gadget a *trochobrum*. Push-pull, click-click . . . you're an engineering gentleman, and a scholar too. —WG

Nuclear Technology for Engineers

R HOBART ELLIS JR, Nucleonics Magazine. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36. 6¼ x 9¼, 284 pp. $9.50.

This is a basic text, suitable for college courses, and incorporating many of the standard diagrams. It can serve as a brush-up for those who know "a little" but want a little more on a specific point. It seems to be written primarily for those interested in radiation and its applications, since relatively little attention is paid to reactors and chain reactions.

Amino Resins

JOHN F BLAIS. Reinhold Publishing Corp, 430 Park Ave, New York 22. 8 x 6, 220 pp. $4.95.

Covers the chemistry, manufacture and major applications of urea and melamine resins, and the newer ethylene urea and benzoguanamine. The book describes in detail amino resin applications in adhesives, molding, laminating, textiles, paper and surface coatings. Previously only a modest amount of technical information was available on this resin group, but the recent expiration of some basic pat-

(continued on page 78)

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ents has created wide interest. This book satisfies the need for additional data. The applications included represent large volume outlets for amino resins. Existing and potential users have here a concise treatment of the amino resins and their uses.

Servo Engineer's Handbook

Daystrom Transicoil, Division of Daystrom Inc, Worcester, Penna. 5¾ x 8¼, 129 pp. $3.

A good primer on electrical servos. It assumes no prior knowledge, and deals specifically with the components and does not attempt to explain complex servo theory. Elementary theory, including some circuit analysis, block diagrams, stability criteria and testing methods are given. Chapters start with excellent cutaway photos of the major component discussed. Included are servomotors, rate generators, synchros, gear trains, and servoamplifiers.

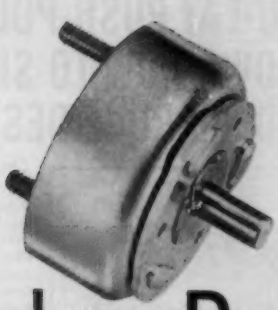
Phenolic Resins

DAVID F GOULD. Reinhold Publishing Corp, 430 Park Ave, New York 22. 8½ x 6, 213 pp. $5.75.

Here is a concise presentation of the raw materials, production methods, and applications of the phenolic resins. The book emphasizes the practical features, including commercial and economic considerations, describing each major field of application in separate chapters. Numerous disclosures in patents and elsewhere serve as a basis for the development of new uses for the phenolics. There is also information on the use of phenolics in combination with other resins. Engineers, designers, architects and management have here a complete picture of present and potential uses of phenolic resins.

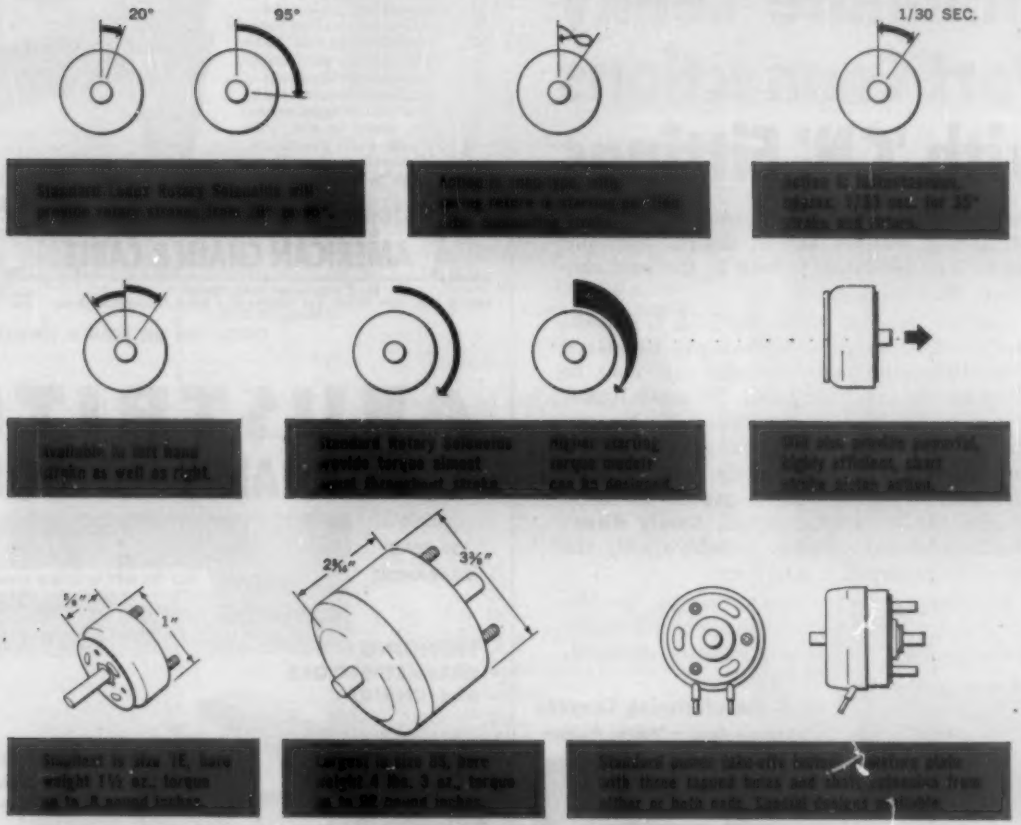
(continued on page 81)

". . . He's designing a vending machine that will dispense vending machines! !"



Ledex Rotary Solenoid

BASIC INFORMATION

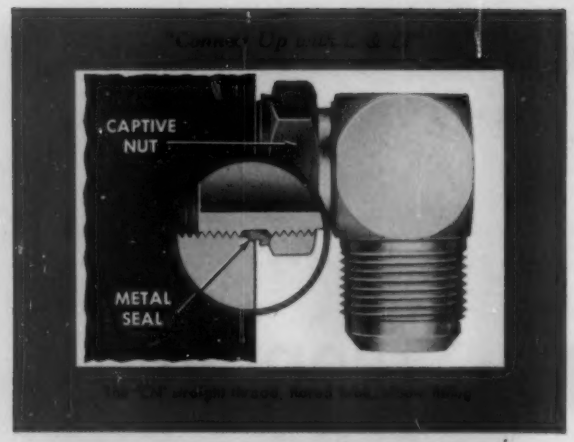


The Ledex Method of actuation and control gives instantaneous high-torque-to-size rotary motion and high-thrust-to-size piston motion, for reliable remote mechanical actuation or remote control of rotary-type switches.

The efficient Ledex Rotary Solenoid is the heart of this method. Available in 8 compact sizes, with operating voltage from 3 to 300 V.D.C. Over 24[illegible] stock models ready for imme[illegible]ate shipment. Used in thousands of applications including valves, tape recorders, waveguide switches, sorting equipment, gyrocaging, computers, wireless teletypes, vending machines, typesetters, missile guidance and ground support equipment.

Other Ledex Method products are Syncramental Stepping Motors, Rotary Stepping and Selecting Switches. Write for Bulletin A-1259, mentioning application, to G. H. Leland, Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.; NSF GmbH, Nurnberg, Germany.

CIRCLE 79 ON READER SERVICE CARD



Eliminate Leaky Port Connections with 'CN'® Fittings

Whether using the old pipe-threads or the "new" SAE O-ring straight thread design, hydraulic tube fittings are prone to leak at the port connection. That's a fact.

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At no greater cost — standardize on trouble-free 'CN' hydraulic tube fittings—as inevitable as progress itself, the coming industry standard.

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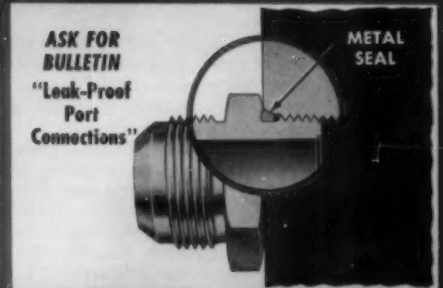
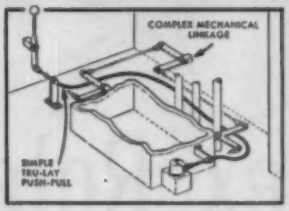


TRU-LAY PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY AND IMPROVE DESIGN



Push-Pull remote controls, shown here, are flexible, have but one moving part, and give a lifetime of accuracy. Mechanical linkages are complex, are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.

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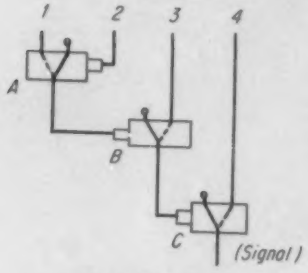
CIRCLE 205 ON READER SERVICE CARD

Moleculonics

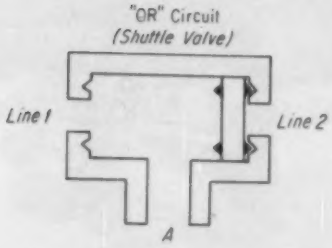
EDWARD L HOLBROOK, Modernair Corp, 5007 Brookpark Rd, Cleveland 34. 2 x 7, 54 pp. $1.

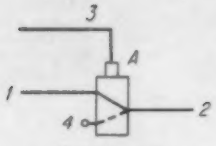
This simple pneumatics booklet, though published by a pneumatics company, has a fairly general approach. It is dedicated to the belief that air circuits can perform logic as well as do work.

The author has sketched typical pneumatic circuits (some accompany this review) that will perform logic functions such as AND, OR, NOT and MEMORY. As examples, he has also drawn actual circuits that use such logic–protective circuits, packaging systems, and so forth.

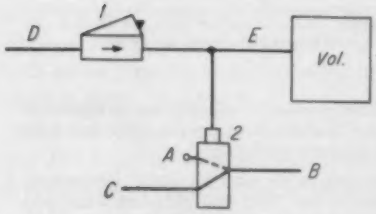


"AND" Circuit



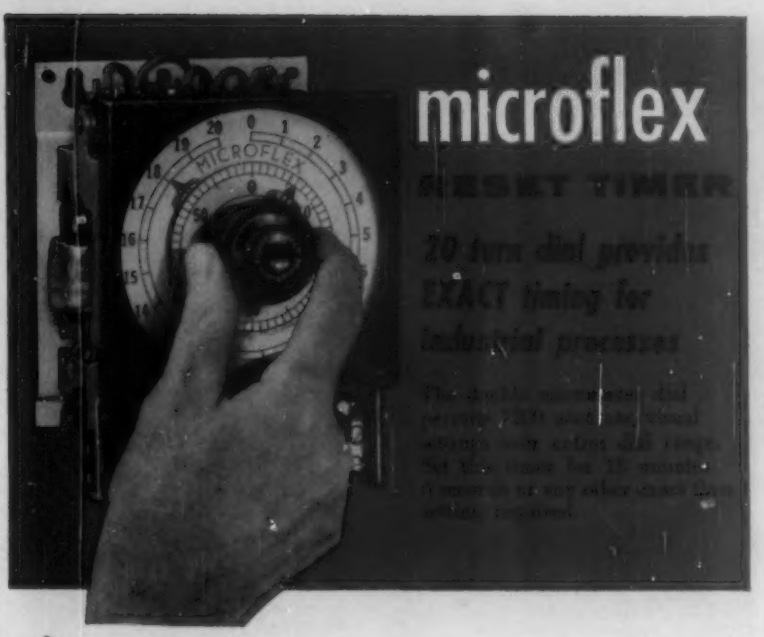


"NOT" Circuit



"MEMORY" Circuit

(Continued on page 84)



Savings

- Large 15 ampere contacts eliminate additional load relays.
- Stop down time with plug-in components for fast timer replacement.

Flexibility

- Easy to set dial whether short or long timing.
- Choice of 9 actions available for each of 3 contacts. Select operation required for your circuit.

Accuracy

- Set dial to exact time required. No guessing at numbers.
- Accurate repeatability insures uniform production.

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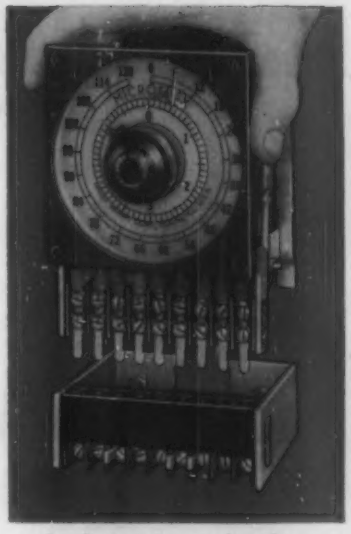
- Proven reliability in thousands of industrial processes for more than 25 years.



Install timer in seconds with optional plug-in feature.

Eagle Timers Save Time — Save Money

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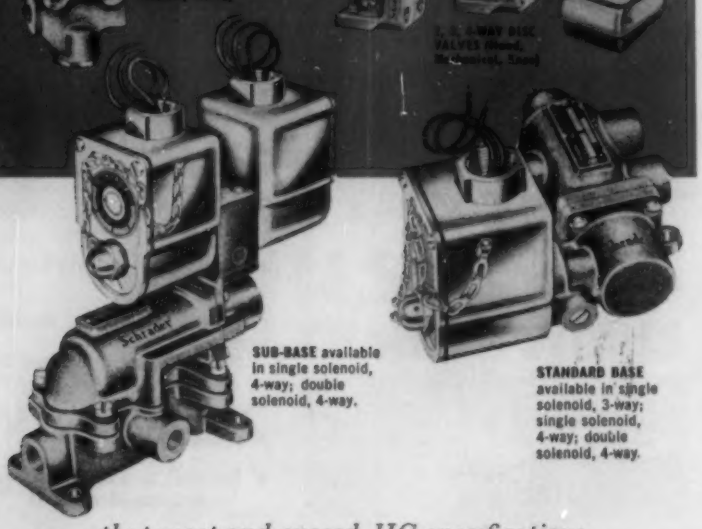

SUB-BASE available in single solenoid, 4-way; double solenoid, 4-way.

STANDARD BASE available in single solenoid, 3-way; single solenoid, 4-way; double solenoid, 4-way.

New JIC Solenoid Valves are compact, rugged, fast-and-easy to install. Roomy junction boxes fit space requirements with 90° rotation. Can be operated in case of current failure, by hand. Safe, recessed override button prevents accidental operation. Electrical system completely sealed against dust, oil.

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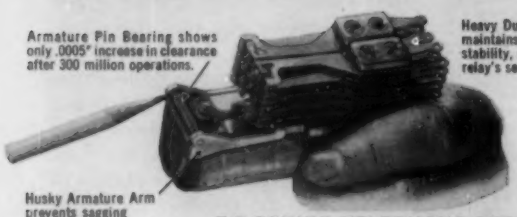
HERE'S WHY P&B TELEPHONE TYPE RELAYS GIVE YOU

reliable performance over long life


Armature Pin Bearing shows only .0005" increase in clearance after 300 million operations.
Heavy Duty Frame maintains dimensional stability, adds to relay's sensitivity.
Husky Armature Arm prevents sagging or bending.

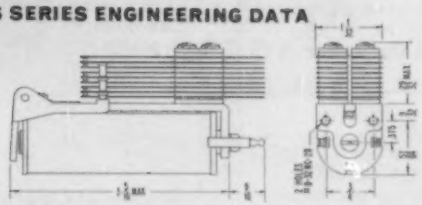
BS SERIES TELEPHONE TYPE

Measure the thickness of the BS series armature arm. You will find the cross section area is greater than ordinary relays of this type. Here is the kind of quality that spells dependability.

Observe that the stainless steel hinge pin runs the full width (not just half) of the armature, providing optimum bearing surface. This pin, operating in a stainless steel sleeve, shows only minimal wear during nearly a *third of a billion operations.*

Best of all, P&B quality costs no more. A whole new plant is being devoted to the production of high performance telephone type relays. Your nearest P&B sales engineer will be happy to discuss your relay problems. Call him today.

BS SERIES ENGINEERING DATA



GENERAL:
- **Breakdown Voltage:** 1000 volts rms 60 cy. min. between all elements.
- **Ambient Temperature:** −55° to +85° C. +125° C available on special order.
- **Weight:** 9 to 16 ozs.
- **Terminals:** Pierced solder lugs; Coil: One #16 AWG wire Contacts: Two #18 AWG wires
- **Enclosures:** Dust covered or sealed

CONTACTS:
- **Arrangements:** DC—up to 28 springs AC—up to 24 springs
- **Material:** ⅛" dia. twin palladium. Up to ¼" dia. single silver. Other materials on special order.
- **Load:** 4 amps at 115 volts, 60 cycle resistive
- **Pressure:** 15 grams minimum

COILS:
- **Resistance:** 100,000 ohms maximum Current: 10 amps maximum
- **Power:** DC—50 Milliwatts per movable arm. Greater sensitivity on special order. AC—17.9 volt-amps.
- **Duty:** Continuous
- **Treatment:** Centrifugal impregnation
- **Voltages:** DC—up to 300 volts with series resistor. AC—up to 250 volts, 60 cy.

MOUNTING: Two #8-32 tapped holes ¾" o.c. Other mountings on special order.

GS SERIES—Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.

LS SERIES—Medium coil relay with short springs and light weight armature for fast action, reliability and long life.

TS SERIES—Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

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ROTARY multi-pole multi-circuit SWITCHES

— standard or special —
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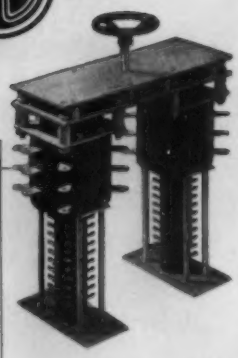
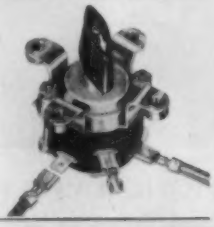
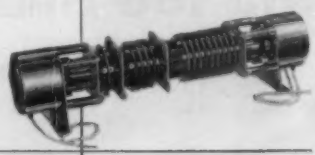
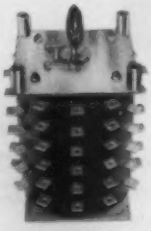
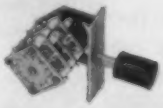
for simple or complex circuit control.

Here are typical designs that show
the versatility of Esco construction.

Write for Bulletin 8A or call us for details.

Style and Size	Loads and Circuits	
Single-control tandem pair; snap-action; 7 × 19 inches × 20 inches behind panel. 75 lbs. approx.	200 amps. 500 v. a-c 6-pole, triple-throw; 30 amps. 500 v. a-c 20-pole, triple-throw.	
Quick-connect terminaling for snap-on wiring; 3¼ inches diameter, 3 inches behind panel. 8 oz. approx.	10 amps. 125 v. a-c single-pole 4-position; snap action.	
2-way drive by 6-volt solenoids; 3⅞ inches diameter, 18½ inches long. 12 lbs. approx.	10 amps. 125 v. a-c 34 poles, 2 positions.	
High-current low-voltage tap switch; 10¾ × 10¾ inches, 14 inches behind panel. 25 lbs. approx.	150 amps. 6 v. a-c 6-pole 12-position.	
Lever-actuated miniature switch; 1¼ × 1¾ inches. 1¼ inches behind panel. 2 oz. approx.	3 amps. 125 v. a-c 4-pole 3-position.	
3-gang, gear-drive single-control switch; 6⅞ × 7¼ inches × 14 inches behind panel. 25 lbs. approx.	5 amps. 125 v. d-c 75 poles 2 positions.	

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Engineering Economics for Professional Engineers' Examinations

MAX KURTZ. McGraw-Hill Book Co, 330 W 42nd St, NY 36. 5½ x 8¼, 261 pp. $6.50.

In this one volume are all the facts, formulas, tables needed to save time and insure accuracy in answering questions likely to arise in the economics section of the Professional Engineer examination. Covered in detail are: media of investment, time value of money, sinking funds and annuities, ammortizations of loans, valuation of bonds, depreciation, depletion. Technical terms are defined and mathematical principles reviewed. Many exercises and problems—typical of those asked in actual examinations throughout the country—are included, mostly with worked-out solutions or answers.

Contribution from the Museum of History and Technology

US National Museum Bulletin 218, Papers 1-11, Government Printing Office, Washington 25, DC. 8¾ x 11½, 201 pp. $2.50.

The staff of the Museum of History and Technology, a young subdivision of the Smithsonian Institution's National Museum, has published its first collection of papers dealing with technological history. This handsomely illustrated book contains eleven papers on such subjects as: John Deere's steel plow, the beginning of cheap steel, the origin of clockwork, perpetual motion devices and the compass. Science historians and those just curious about early engineering will find this government publication most interesting.

Practical Design of Sheet Metal Stampings

FEDERICO STRASSER. Chilton Co, Philadelphia 39. 9 x 6, 175 pp. $10.

Covers basic concepts and design details on processes for making products from sheetmetal. Although the book contains little that is new, its author has assembled much valuable design information from his own articles, some previously published in PRODUCT ENGINEERING, as well as in *Iron Age* and other sources. Two faults mar its usefulness: It is slightly

(continued on page 86)

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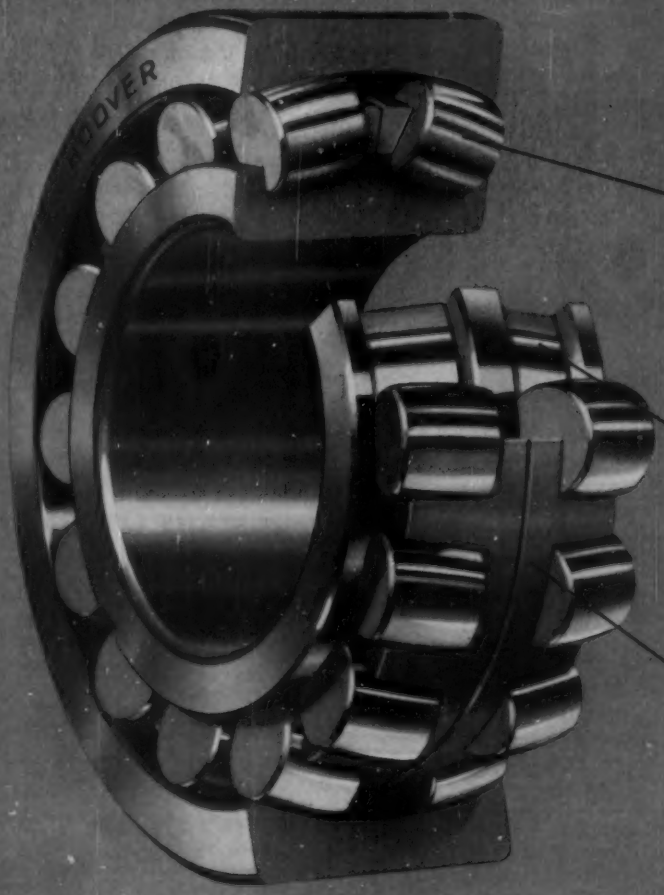

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biased in favor of stamping when comparing it with competitive processes, and the separation of text from matching illustration sometimes makes reading a chore.

The Magnacard System

ALFRED M NELSON. WADC Technical Report 58-421. Available from Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8½ x 11, paperbound, 177 pp. $3.

Although the punched card has limited storage capacity and slow reading speed it is still the most popular means for storing fixed units of information. Now the development of the Magnacard promises to eliminate both these disadvantages while retaining the greater handling convenience of punched cards compared with magnetic tape, or other continuous storage methods. This report (full title: "Research and Development of the Magnacard System") summarizes details of research and development on the Magnacard project sponsored jointly by Wright Air Development Center and The Magnavox Company.

Information that can be packed on a 1 x 3 in. oxide-coated Mylar card is over 10 times that available on a conventional punched card (1000 characters compared with 80 or 90) while reading speed can be boosted to 300 in. per sec, or more than twice as fast as any tape transport in use today. In the machine, feeding and transporting of cards is accomplished pneumatically. This report outlines design details of vacuum drums and electrodynamic air valves developed for transfer operations that form the basis of sorting and selecting functions. Also included is a study of suitable card materials, design of mechanical equipment for transporting, stacking, transferring, filing and electronic circuitry for reading, writing and transcribing.

Product Engineering Design Manual

DOUGLAS GREENWOOD. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 8½ x 11, 340 pp. $9.

How many ways can you . . . join sheetmetal parts without fasteners . . . feed parts from hoppers . . . design an overrunning clutch . . . couple small-dia shafts . . . lubricate ballbearings . . . test springs? Which adhesive . . . fractional-hp motor . . . microswitch . . . flexible coupling . . . automatic timer . . . for which application? The Design Manual answers these and many other similar questions. It includes for the first time in one volume the most significant, practical design-file pages published in PRODUCT ENGINEERING. Hundreds of illustrations and many useful nomograms and charts give needed how-to information, helpful to both the beginner and experienced designer.

". . . Okay! . . . now that we have decided on the color . . . How will we build it! !"

Experts in many fields have contributed valuable information and practical design data not found in any engineering handbook or textbook. Careful editing and arranging made it easy to locate any topic quickly.

Electrical Engineering for Professional Engineers' Examination

JOHN D CONSTANCE. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 5½ x 8¼, 447 pp. $9.50.

This aid to preparing for electrical engineering questions on the Professional Engineer examination provides two things any refresher should have: a quick run-through of theory with methods of application; a large number of questions typical of those generally asked in the examinations. Text includes dc theory, magnetism, dc machines, ac theory, ac machines and equipment, electronic tubes and circuits.

ABSTRACTS FROM THE LITERATURE

Rocket-engine Materials

An analysis of material applications in high-temperature environment in rocket engines is made. The problems are examined from the point of view of the designer, the manufacturer, and the quality control engineer. Stringent requirements can be met with relatively common materials by good design and careful manufacturing techniques.

"Application of Materials to High-temperature Service in Rocket Engines," R. P. Fromberg, Rocketdyne Div, North American Aviation Inc. SAE paper No 98V, 485 Lexington Ave, New York 17.

Shop Noise

Measurement and description of shop noise, acceptable sound levels, main noise sources in equipment and small plants and corrective action are discussed. Includes bibliography.

"Keeping Shop Noise from Nearby Residences," H. C. Hardy, Howard C. Hardy Associates. Available without charge from Small Business Administration, Washington 25, D C.

Safety Factor in Design

Traditionally, a safety factor has qualitative meaning only, but it can be quantitatively interpreted through possible variations in the components

(continued on page 89)

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NEW YORK.....50 E. 42nd St., New York 17, MU 7-1283
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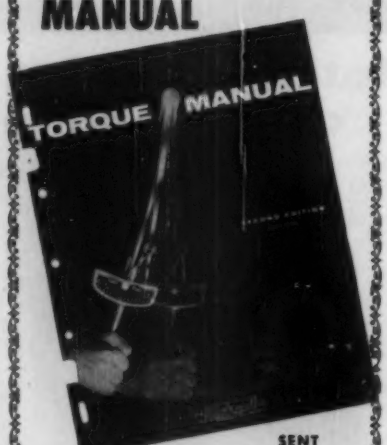
"TORQUE WRENCH" MANUAL



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of a design, as well as the probability of safety. A proposed statistical method for determining safety factors that is said to give a more rational and more economic design than conventional methods is described and demonstrated.

"Design by Quantitative Factor of Safety," Hsuan-Loh Su, Imperial College, London; ASME paper 59-2-48. 29 W 39th St, New York 18.

Design Piracy

Supposed advantages of piracy, dangers, and other considerations (aside from moral questions) are discussed.

"Design Piracy—Unethical or Foolish?" James Warren, Industrial Design Professor, National College of Arts, Lahore, Pakistan. Design Engineering, Nov '59, 481 University Ave, Toronto 2, Ont.

Radiation of Silicone Greases

Silicones as a class have been termed poor in radiation stability. This refers to silicones containing a major amount of methyl substituents and little or no phenyl substitution. Actually, some fluid silicones are very stable in radiation environments. This report points out the degree of radiation stability of these fluids and the extrapolation of this characteristic to grease formulations.

"Radiation Stability of Silicone Greases," Fischer, Zack Jr, and Warrick, Dow Corning Corp; Lubrication Engineering, Oct '59, 5 N Wabash Ave, Chicago 2.

Criteria for Reliability

Design criteria for reliability discussed in this paper include concepts of environments, strengths, strength-environment separation factors, allocation of unreliability values to ele-

(continued on page 91)

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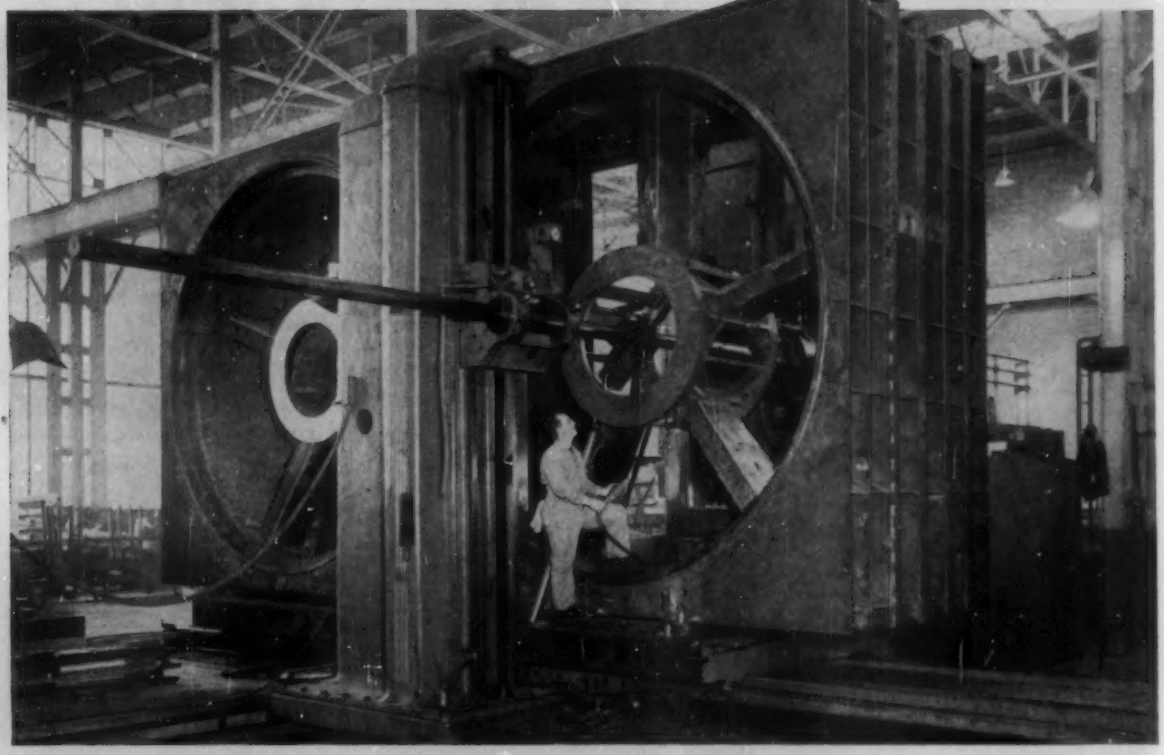

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ments of a system. Possible design procedures which result from three different types of testing are discussed. Various criteria concepts and techniques for evaluating reliability are demonstrated with an example based on a mechanical element.

"Reliability Design Criteria," Brown, Love and White, Hughes Aircraft Co; SAE paper 101V, SAE, 485 Lexington Ave, New York 17.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 93

HIGH-ALLOY CASTINGS – Bulletin G-159, 20 pp. Covers static, centrifugal and shell-molded castings. Includes physical properties table for corrosion-resistant, heat-resistant and abrasion resistant alloys; standard designation and stress temperature curves for selected high alloys. Duraloy Co, Scottdale, Penna.

Circle 340 on Reader Service Card

MINERAL-INSULATED THERMOCOUPLES–Catalog 300, 20 pp. Includes features and specifications of mineral-insulated thermocouples, hot-junction terminations and mounting methods. Conax Corp, 2300 Walden Ave, Buffalo 25.

Circle 341 on Reader Service Card

HERMETIC AND PROTECTIVE ENCLOSURES–Catalog, 32 pp. Describes line of hermetically sealed and protective enclosures for relays, switches and control packages. Seventy photos and 150 line drawings show housing sizes and shapes. Automatic Electric Co, Northlake, Ill.

Circle 342 on Reader Service Card

TEFLON SHAPES–Catalog TFE 359, 8 pp. Catalogs available shapes and sizes, together with permissible tolerances, properties and end-use applications. Cadillac Plastic & Chemical Co, 15111 Second Blvd, Detroit 3.

Circle 343 on Reader Service Card

ELECTRIC VIBRATORS–Brochure, 12 pp. Gives descriptions, specifications and performance information for 14 standard bin vibrators. Seventeen illustrations show typical installation. Syntron Co, 240 Lexington Ave, Homer City, Penna.

Circle 344 on Reader Service Card

SUBMINIATURE AIR-CONTROL VALVES–Bulletin 592, 12 pp. Contains specifications and performance information on valves 1 x 1¼ in. Cutaway view shows

(continued on page 92)

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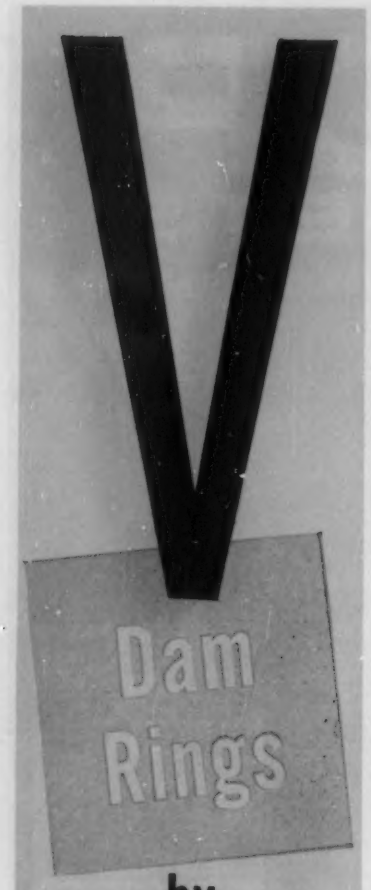

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valve action. Includes illustrations of each of 6 available valve actions, dimensional drawings, descriptions and JIC diagrams for each valve action. Hunt Valve Co, Salem, Ohio.

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STANDARD FLEXIBLE-SHAFT ASSEMBLIES—Catalog, 8 pp. Presents over 180 variations of flexible shaft assemblies, produced from stock components. Gives dimensions and ratings. F W Stewart Corp, 4311-13 Ravenswood Ave, Chicago 13.

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INSTRUMENTS FOR SWITCHBOARD USES—Catalog 4220, 24 pp. Covers 13 types of switchboard instruments, with descriptions, information on mechanism types, accuracy, scale length, rating, terminals, dimensions, weights, cases and list prices. Roller-Smith Inc, 50 Ave L, Newark 1, NJ.

Circle 347 on Reader Service Card

STANDARD PLATE AND FACE CAMS—Catalog 900, 8 pp. Lists about 100 standard units by stroke, timing and load rating. Graphs relate stroke, min movement time and size of cam blank. Discusses design, manufacturing processes, application and installation. Ferguson Machine Corp of Ind, 7818 Maplewood Industrial Court, St. Louis 17.

Circle 348 on Reader Service Card

PROCESS TIMERS – Bulletin GEZ-2985, 4 pp. Describes adjustable "on" time units. Includes features, application information, ratings, dimensions, prices. General Electric Co, Schenectady 5.

Circle 349 on Reader Service Card

VARIABLE-SPEED SHEAVE – Bulletin 6102, 8 pp. Pictures and describes stationary-control variable-speed sheave for standard V-belts. Exploded view shows various components. T B Wood's Sons Co, Chambersburg, Penna.

Circle 350 on Reader Service Card

TORQUE CONVERTERS—Folder FFS-5, 4 pp. Industrial torque-converters in 14-, 15- and 16-in. sizes and optional equipment are described. Clark Equipment Co, Automotive Div, Jackson, Mich.

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RACK-AND-PANEL CONNECTORS—Brochure, 4 pp. Specifications and features of connectors and coaxial cable to assist in proper selection. Schweber Electronics, 60 Herricks Rd, Mineola, NY.

Circle 352 on Reader Service Card

PREDETERMINING COUNTERS – Form 227773, 4 pp. Describes and illustrates several major types of mechanical, electromagnetic and photoelectric counters incorporating predetermining feature. Veeder-Root Inc, Hartford 2.

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TEFLON SHAFT SEAL—Bulletin S-233, 4 pp. Covers design and characteristics of seal for corrosive service. Crane Packing Co, Dept PE-1, 6400 Oakton St, Morton Grove, Ill.

Circle 354 on Reader Service Card

HEATING ELEMENTS – Bulletin VG-100, 4 pp. Presents representative selections from each line of electric heating elements. Vulcan Electric Co, 88 Holten St, Danvers, Mass.

Circle 355 on Reader Service Card

PEROXYGEN CHEMICALS – Bulletin list, 8 pp. Lists titles, numbers and contents of available bulletins covering such topics as product descriptions; properties and reactions; metal treatments. Becco Chemical Div, Food Machinery and Chemical Corp, Station B, Buffalo 7.

Circle 356 on Reader Service Card

SAFETY-HEAD ASSEMBLIES—Catalog 459, 4 pp. Contains dimensional information for designs of 64 safety-head assemblies for use with Baker rupture disks. High Pressure Equipment Co Inc, Erie, Penna.

Circle 357 on Reader Service Card

SWITCHES, RELAYS, GRAVITY-SENSING POTENTIOMETERS—1960 catalog, 6 pp. Presents actual-size illustrations with descriptions. Typical applications are shown along with diagrams covering many types of actuating mechanisms. Hamlin Inc, Lake and Grove Sts, Lake Mills, Wis.

Circle 358 on Reader Service Card

REMOTE CONTROL SYSTEM—Brochure, 4 pp. Gives features, dimensions, accessories, uses and installation information on closed hydraulic system for remote motion control or duplication. Hydronic Corp, 12685 Arnold, Detroit 39.

Circle 359 on Reader Service Card

HI-TEMP HYDRAULIC PUMPS AND MOTORS—Brochure, 4 pp. Covers ratings, features and design of pumps and motors for high-temperature hydraulics systems. Performance charts show effect of inlet temperature on pump performance at full flow, full pressure and through cutoff at rated speed for typical pump models. Pesco Products Div, Borg-Warner Corp, 24700 N Miles Rd, Bedford, Ohio.

Circle 360 on Reader Service Card

SWITCHES—Condensed catalog and price list, 4 pp. Specifications, mounting information and diagrams, and dimensions of basic snap-action, enclosed snap-action,

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foot, mercury and actuating switches. Pic Automation Controls Div, General Controls Co, 8072 McCormick Blvd, Skokie, Ill.

Circle 361 on Reader Service Card

PANEL INSTRUMENTS—Catalog 59-1, 8 pp. Specifications and dimensions of panel instruments. With illustrations, prices and ranges available. Triplett Electrical Instrument Co, Bluffton, Ohio.

Circle 362 on Reader Service Card

COMPRESSION-FORMED TUBING—Bulletin SP-1, 4 pp. Discusses design and fabrication advantages, configurations and performance of tubing formed by process that controls ID and OD, reducing wall thickness as length of tube is increased. Tube Reducing Corp, PO Box 959, Passaic, NJ.

Circle 363 on Reader Service Card

ELECTRICAL CONTACTS — Catalog 601, 4 pp. Describes materials, properties, forms and uses of line of electrical contacts. Gibson Electric Co, Box 634, Delmont, Penna.

Circle 364 on Reader Service Card

SECTIONALIZED MOTORS — Specification sheets S900-7 and S900-6, 6 and 4 pp. Contain electrical and physical information on sectionalized servomotor and synchronous fhp unidirectional motor, respectively. Minneapolis-Honeywell, Wayne and Windrim Aves, Philadelphia 44.

Circle 365 on Reader Service Card

INDUSTRIAL WIRE CLOTH—Bulletin, 4 pp. Describes and illustrates line of wire cloth. Includes information on selection, ordering and quality checking. Newark Wire Cloth Co, 351 Verona Ave, Newark 4, NJ.

Circle 366 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

RELAYS—Folder R-200, includes 13 data sheets. Data sheets for 5 and 10 amp and specialty relays present dimensions, coding information and specifications. Relay Div, Electronic Specialty Co, 5121 San Fernando Rd, Los Angeles 39.

CONTROLS AND MOTORS—Bulletin IS-6013, 4 pp, in file folder. Describes controls and motors originally designed for vending machine applications, including controls for mixing, measuring, starting, and stopping plus automatic regulation of flow refrigerants and rotary or lateral motions. Marketing Manager, Vending Machine Controls, Controls Co of America, Schiller Park, Ill.

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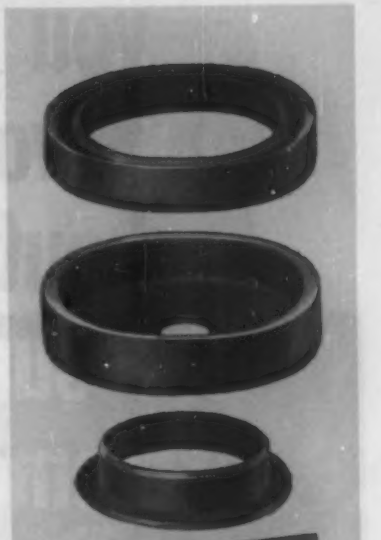

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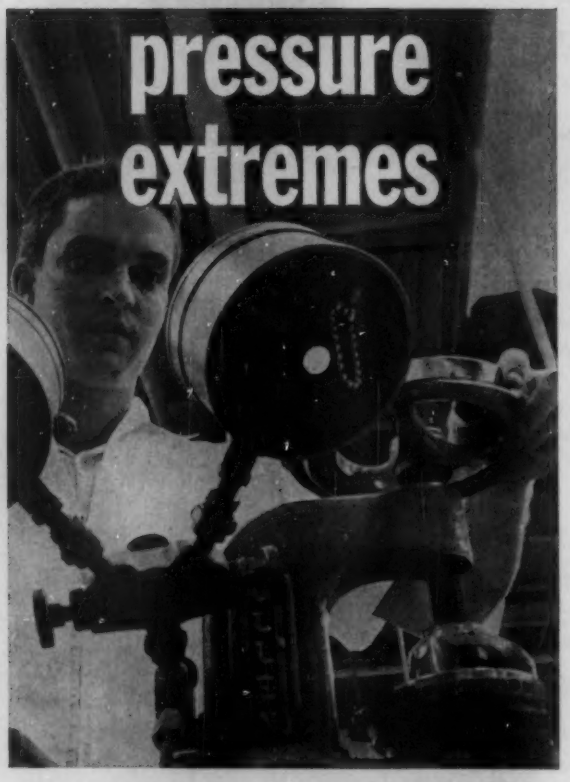

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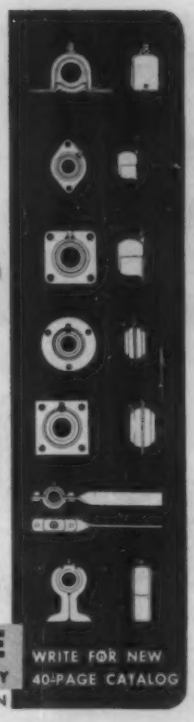

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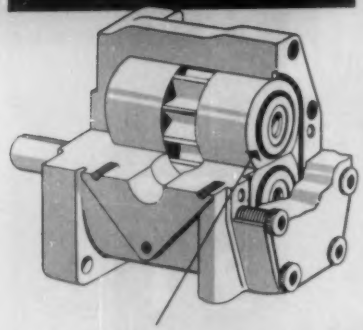

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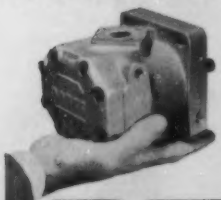

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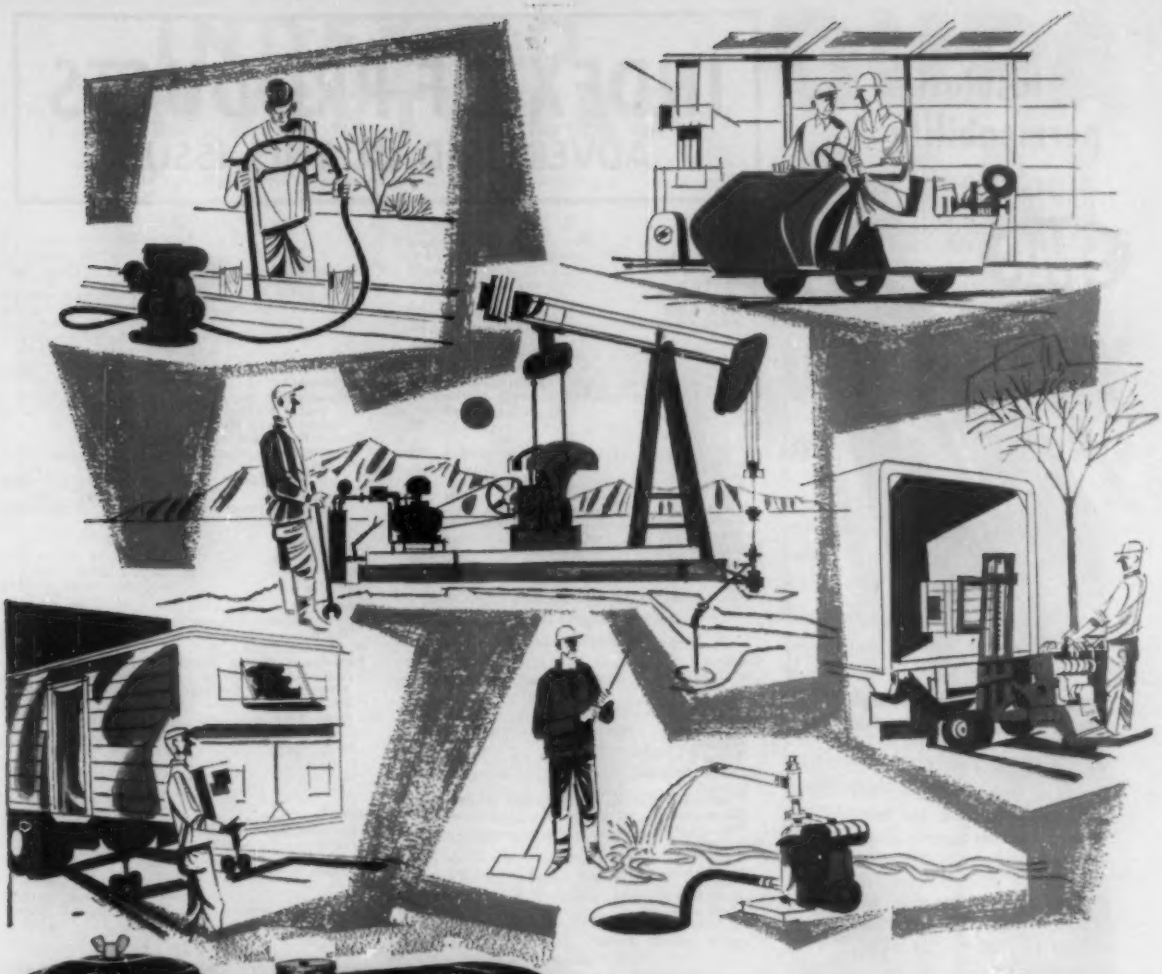

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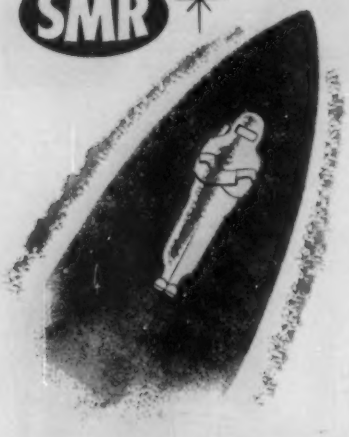

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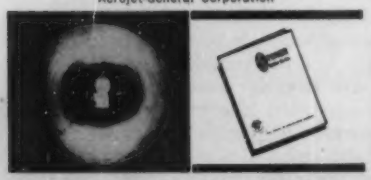

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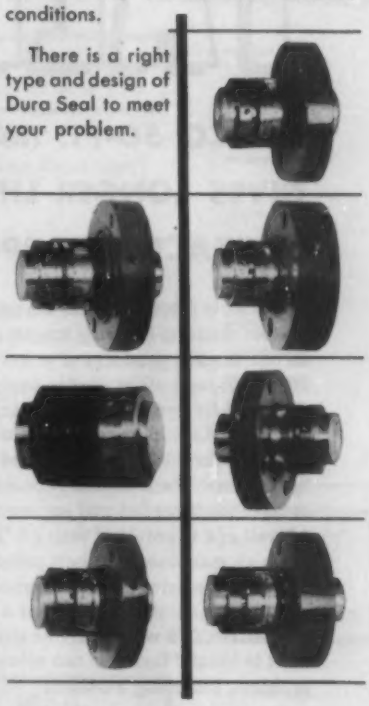

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Issue of January 18, 1960

Product Engineering

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P15—8 STEPS TO BETTER ENGINEERING WRITING—9/7—10/26

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P21—MECHANICAL RELIABILITY—11/16

P22—HIGH-TEMPERATURE REINFORCED PLASTICS—11/23

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366—Industrial Wire Cloth, 4 pp, Newark Wire Cloth Co.

NON-METALLIC MATERIALS, FINISHES

343—Teflon Shapes, 8 pp, Cadillac Plastic & Chemical Co.

356—Peroxygen Chemicals, 8 pp, Food Machinery and Chemical Corp.

FABRICATION PROCESSES AND PRODUCTION

363—Compression-Formed Tubing, 4 pp, Tube Reducing Corp.

POWER TRANSMISSION

346—Standard Flexible-shaft Assemblies, 8 pp, F W Stewart Corp.

350—Variable-speed Sheave, 8 pp, T B Wood's Sons Co.

351—Torque Converters, 4 pp, Clark Equipment Co.

MECHANICAL PARTS

342—Hermetic and Protective Enclosures, 32 pp, Automatic Electric Co.

348—Standard Plate and Face Cams, 8 pp, Ferguson Machine Corp of Ind.

354—Teflon Shaft Seal, 4 pp, Crane Packing Co.

MOTORS, ENGINES AND CONTROLS

359—Remote Control System, 4 pp, Hydronic Corp.

365—Sectionalized Motors, 6 and 4 pp, Minneapolis-Honeywell.

ELECTRICAL, ELECTRONIC COMPONENTS

341—Mineral - Insulated Thermocouples, 20 pp, Conax Corp.

WEALTH OF VITAL INFORMATION . . .

NEW COMPONENTS

GENERAL ENGINEERING

325—Dynamic Pressure Calibrator

326—Vertical Blueprint Safe

NON-METALLIC MATERIALS, FINISHES

306—Nylon-plastic Conveyor Belting

320—Metallized Polyester Film

FABRICATION PROCESSES AND PRODUCTION

310—Portable Plasma Flame Spray Gun

311—Holes of Less Dia Than Thickness

POWER TRANSMISSION

313—19 to 55% Greater Load

FASTENING AND JOINING

303—Miniature ¼-turn Fastener

309—Elastomeric-base Adhesive

323—Right-angle Bracket Nut

MOTORS, ENGINES AND CONTROLS

319—60 Cps Motor Generator

ELECTRICAL, ELECTRONIC COMPONENTS

300—Binary Thumbwheel Switch

302—Measuring Controller

305—Programming Timer

307—Thermocouple Probe

308—Miniature Coaxial Switch

312—Low-cost Silicon Transistor

317—Motor Load Indicator

318—2-circuit Pushbutton Switch

HYDRAULIC, PNEUMATIC EQUIPMENT

301—Rotary Valve Actuator

304—Helical Rotor Pumps

314—Low-pressure Cylinders

315—Nylon Pressure Tubing

316—High-pressure Piston Pump

321—Miniature 4-way Control Valve

322—4-way Solenoid Valve

324—Non-linear Gas Density Switch

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355—Heating Elements, 4 pp, Vulcan Electric Co.

358—Switches, Relays, Gravity-sensing Potentiometers, 6 pp, Hamlin Inc.

361—Switches, 4 pp, General Controls Co.

362—Panel Instruments, 8 pp, Triplett Electrical Instrument Co.

364—Electrical Contacts, 4 pp, Gibson Electric Co.

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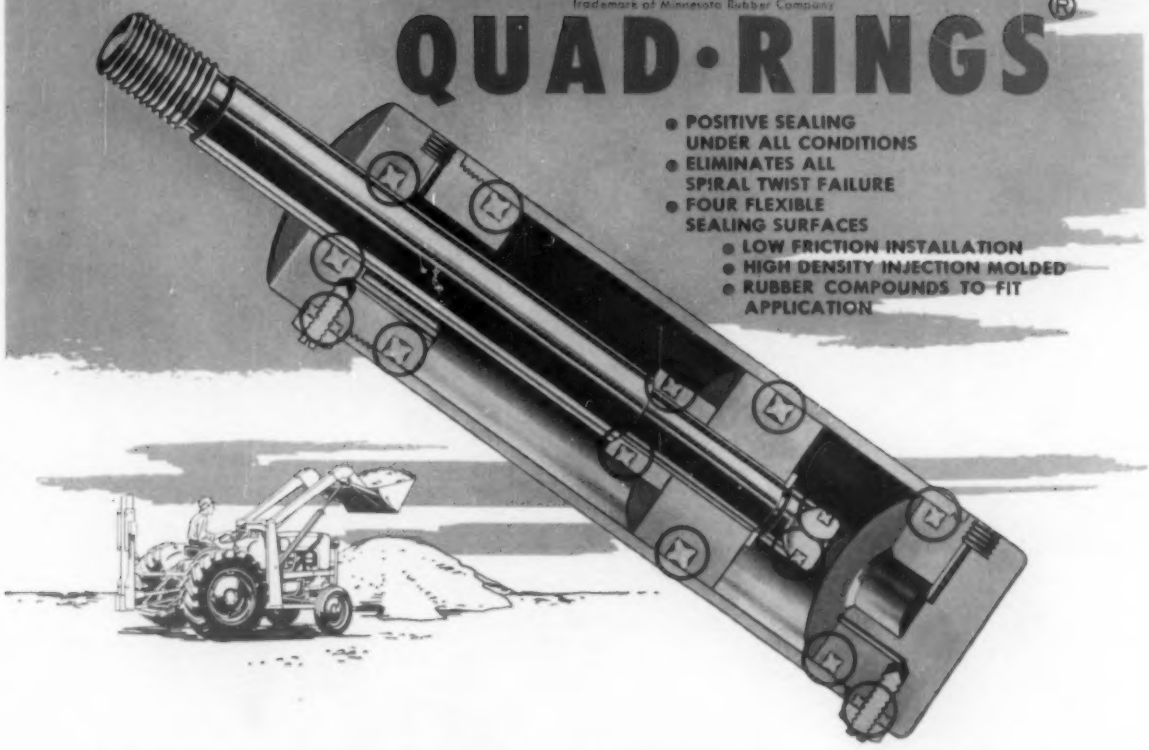

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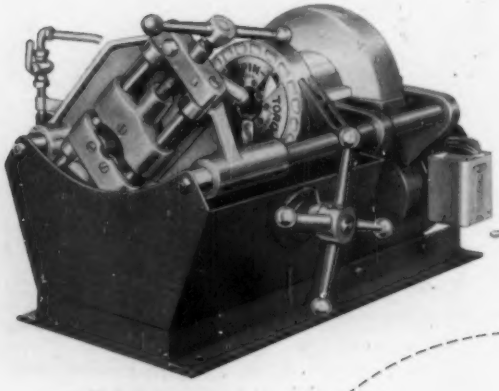

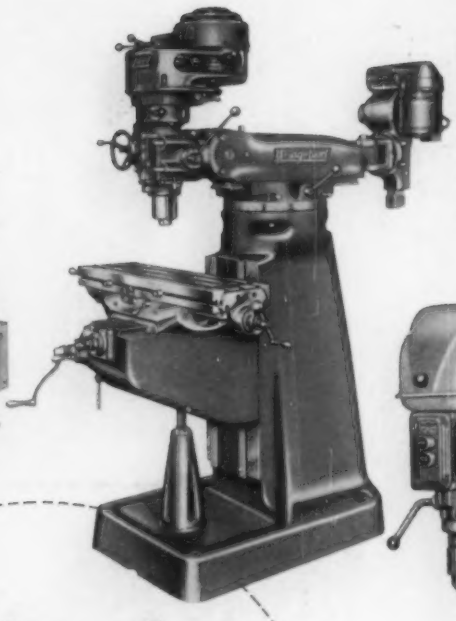

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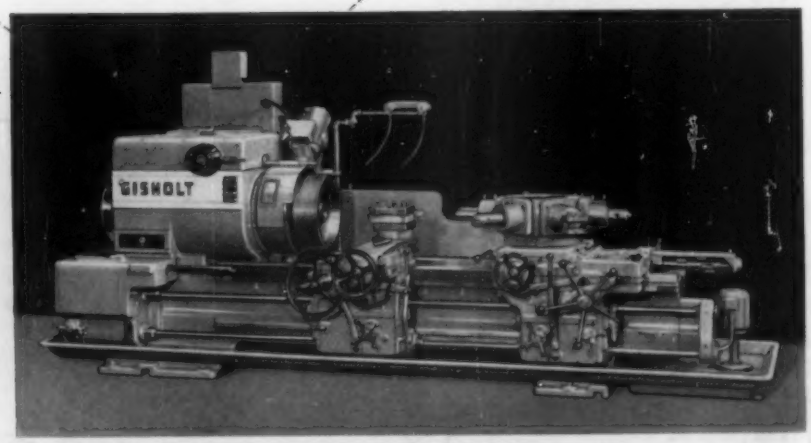

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